February, 1979
Price, $2.00

Technology Review

Edited at the Massachusetts Institute of Technology

New Technologies for Steelmaking

Also:

The Risks of Daily Life
Energy from Hot Dry Rocks
Subjectivity and Science

technology
review
Published by MIT

Is high Diesel mileage a myth? Ask Robert J. O'Reilly, whose Mercedes-Benz 180D has rolled up 1,184,880 miles.

Is long Diesel life a myth? Ask Paul F. Dauer, whose Mercedes-Benz 260D is 41 years old – and still going strong.

Mercedes-Benz Diesel Search uncovers million-mile Diesel and 41-year-old Diesel, both still going strong.

It was a quest for hard, cold facts about the legendary Diesels of Mercedes-Benz – and "spectacular" describes the facts that were found.

Item: 10 Diesels with 7.5 million miles between them. Item: In this program, even a 797,855-mile Diesel was an also-ran.

Will that million-mile owner quit while he's ahead? His response: "I fully believe I'll be able to put another million miles on it."

Just how many miles can a Mercedes-Benz Diesel car run?

Just how many years can a Mercedes-Benz Diesel car last?

Despite the myths and tall tales, Mercedes-Benz knows that high mileage and long life – in a Diesel as in any car – depend not just on how well it's built but on careful service and upkeep. On how and where it's driven. And perhaps even on a little bit of luck.

But curiosity remained. And last May 29, Mercedes-Benz launched the Great Diesel Search in a unique quest for the facts.

Timely information

The Great Diesel Search was timed to coincide with the introduction of the most remarkable Diesel car in Mercedes-Benz history – the new 300SD Turbodiesel Sedan.

What better way to usher in this Mercedes-Benz "Diesel of the future" than to document Mercedes-Benz Diesel exploits of the recent past?

The Great Diesel Search lasted 30 days – too brief a time to comb the continent for all 130,000 Diesel cars Mercedes-Benz has sold here.

But time enough to locate a broad cross section. And from Texas to Pennsylvania, from New Mexico to Oregon, Diesel owners responded by the hundreds.

And now the facts are in, authenticated by an independent verifying body. And what these numbers say about the Mercedes-Benz Diesel speaks more eloquently than any words.

7,504,699-mile total

In the high-mileage category, for instance, the top ten Mercedes-Benz Diesel cars had travelled a total of *7,504,699* miles between them.

As the entries mounted, so did the mileage: a 190D with 812,332 miles gave way to a 170SD with 845,289 miles – a feat topped in turn by a 180D that had reached 847,970 miles.

But even this was ultimately not enough. Enter the 1968 220D driven in daily use by Mr. Edward Donaldson of Eugene, Oregon – a Diesel that within ten years had compiled 912,493 miles – the equivalent of two trips from the earth to the moon and back.

To top this achievement would demand a truly phenomenal mileage performer.

And the Great Diesel Search encountered just that: the phenomenal 1957 180D owned by Mr. Robert J. O'Reilly of Olympia, Washington.

Breaking the million-mile barrier

Exact mileage accumulated by the O'Reilly Diesel in its 21 years of service: *1,184,880*. The equivalent of about one hundred years of normal driving. The winner.

With this crowning achievement behind it, will Mr. O'Reilly now retire his 180D to a well-earned rest? Apparently not.

"I fully believe I'll be able to put another million miles on it," he estimates.

10 Diesels, 282 years

In the category of oldest Mercedes-Benz Diesels still registered and running, it was years and not miles that told the tale. The ten oldest cars entered in the Search represented an aggregate 282 years – almost three centuries' worth of dogged Diesel efficiency.

Eight of the top ten finalists dated from 1951 – Diesel cars already rolling along in regular service before almost half the Americans living today were even born.

The granddaddy of them all

But Mercedes-Benz had built the world's first production Diesel passenger car in 1936, 43 years ago. So not even a 27-year-old Diesel could rest on its seniority laurels.

And sure enough, the Great Diesel Search uncovered a car even older – 13 years older, to be precise: the 1938 260D landaulette owned by Mr. Paul F. Dauer of Chicago, Illinois. Imported to the U.S.A. in 1938, recorded as the 902nd Diesel passenger car ever sold by Mercedes-Benz, Mr. Dauer's 260D survives hale and hearty – not some museum piece but a licensed, functioning automobile. The winner.

The rewards...

Mr. O'Reilly with his million-mile Diesel and Mr. Dauer with his 41-year-old Diesel have both been honored by Mercedes-Benz in what seems the most fitting and most timely way.

Each has been awarded a new 300SD Turbodiesel Sedan.

Additionally, several runners-up have received expense-paid European vacations for two.

Four Diesel choices

The results of the Great Diesel Search showed that, for these owners, the promise of the Mercedes-Benz Diesel was kept.

And today's Mercedes-Benz Diesels are engineered and built with a sophistication and precision undreamed of in those pioneering years.

Now you can pick and choose between different Mercedes-Benz Diesel body styles and sizes... engine types... special equipment, from air conditioning to light alloy wheels. Scan the roster:

The new *300SD Turbodiesel* is a potent five-passenger Diesel that approaches a limousine level of comfort.

The *300CD Coupe* is an elegant 2+2 machine designed to compete on equal terms with any other limited-production two-door coupe extant.

The *300D Sedan* is a stirring performer doubling as a sensible five-passenger car, and comprehensively equipped.

The *240D Sedan* is a no-nonsense Diesel in the classic manner: 2.4-liter, 4-cylinder engine and manual 4-speed shift, standard.

See and drive a Diesel

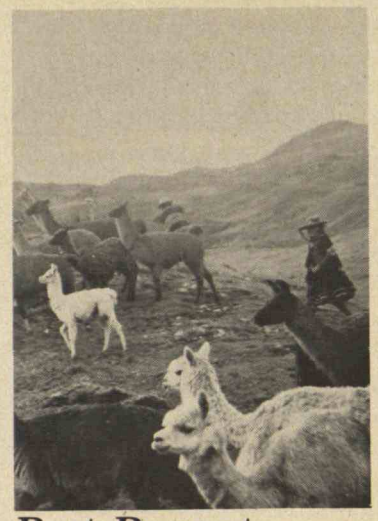
Your local authorized Mercedes-Benz dealer will be glad to arrange a test drive. Call or visit him soon. It could be your first step toward winning the next Great Diesel Search.

Is vivid Diesel performance a myth? Meet the Mercedes-Benz 300SD Turbodiesel, the first performance car to run on diesel fuel.

When you travel as far as the high Andes,

you stay for 3000 years.

NOVA travels to the isolated mountain world of the Q'eros Indians ... where time has stood still for three thousand years ... where the seeming simplicity of their lives conceals a complex pattern of survival. Watch NOVA's *Patterns from the Past.*



Photos: John Cohen

Past. Present. Future.

This month, NOVA looks at the ancient world of Peru's Q'eros Indians ... the man-made wilds of the new super-zoos, where endangered species are getting a second chance ... plus two important programs on possible solutions to the world's devastating energy shortage.

NOVA takes you to worlds you've never seen.

Series of Surprises

Exciting journeys to unusual places. Rare encounters with fascinating people. Meetings with remarkable ideas.

Take NOVA to a new world every week.

NOVA

Thursday, February 8 at 8:00 pm*

* Check local listings

PBS

A COMPANY CALLED

TRW

NOVA is made possible in part by a grant from TRW.

Edited at the Massachusetts Institute of Technology

Volume 81, Number 4
February, 1979

Technology Review

Technology Review, Reg. U.S. Patent Office, is published eight times each year (in June/July, August/September, October, November, December/January, February, March/April, and May) at the Massachusetts Institute of Technology; three special editions are provided for graduate (pp. A1-A24) and undergraduate (pp. A1-A24 and B1-B16) alumni and students (pp. A1-A24, B1-B16, and S1-S12) of M.I.T. *Technology Review* is printed by The Lane Press, Inc., Burlington, Vt. Second class postage paid at Boston, Mass., and at additional mailing offices. Postmaster, send Form #3579 to Technology Review, M.I.T. Room 10-140, Cambridge, Mass. 02139.

Inquiries regarding editorial contents, subscriptions, and advertising should be addressed to: *Technology Review*, Room 10-140, Massachusetts Institute of Technology, Cambridge, Mass., 02139. Telephone: area code (617) 253-8250. Unsolicited manuscripts are welcome, but no responsibility for safekeeping can be assumed.

Price: $2 per copy. Subscriptions: in the U.S., $15 one year., $24 two years, $32 three years. Add $2 per year for Canadian subscriptions. Mexico and overseas $23 one year. $38 two years, $50 three years. Please allow six weeks for changes of address and give both old and new addresses in all requests.

Back issues are $2.50 each for U.S.A. and Canada ($3.00 foreign). Reprints of certain articles are also available.

Technology Review advertising is represented by The Leadership Network: Robert Sennott, Suite 321, 230 Park Ave., New York, N.Y. 10017 (212) 682-4500; Larry Benson, Laurence F. Benson Company, 1411 Peterson Avenue, Park Ridge, Ill. 60068 (312) 692-4695; James L. Latta, Jr., 1400 North Harbor Blvd., Fullerton, Calif. 92635 (714) 879-8930. Also by William T. Anderson, Littell-Murray-Barnhill. 1328 Broadway, New York, N.Y. 10001 (212) 736-1119; and Richard F. Wright, Littell-Murray-Barnhill, 7 Rockwood Road, Natick, Mass., 01760, (617) 653-1568.

Technology Review is a member of the Audit Bureau of Circulation

Articles

Departments

One of the biggest gold strikes since Sutter's Mill.

The yield: 3,000 pounds of pure gold.

But it didn't come from a mine. It came from a Western Electric factory.

A new kind of Midas Touch

That's where Western Electric's new process for plating gold is *conserving* the precious metal, through increased efficiency and precision. It's producing better switching components for the Bell System, to make your phone service clearer and more reliable than ever.

It must be gold that's plated to the switching components you see glittering in the photograph, because no other metal can provide the same kind of efficient, reliable, durable, and clear telephone transmission.

But until now, gold-plating had always been a messy and imprecise process. There had been no way to control it accurately. No way to avoid depositing excess gold on the places it was intended to go. And on the places it wasn't.

So Western Electric, working with Bell Labs, designed a totally new system to do the job. Combining the best of electro-chemical and programmed logic control technologies, the new system can plate gold with hair-thin precision. Depositing only the desired amount, only on the designated spot. With no waste whatsoever.

Gilt-edged savings

Besides producing a much better product, Western Electric has mined a savings of $9 million from the process. And that's another way we're helping your Bell Telephone Company hold down the cost of your phone service.

Even bigger benefits

And since the new process uses 55% less gold than the old one, we could more than double production of our improved switching component. Without consuming any more of the shiny natural resource.

But there are more environmental plusses. The new process has almost completely eliminated the gaseous wastes plating used to produce. It's cut the liquid wastes by 90%. And it runs on 67% less power.

This improved gold-plating technique is another way Western Electric is working to hold down the cost, while continually raising the quality of your phone service.

Keeping your communications system the best in the world.

Western Electric

J. A. Hester

Welcoming a Systems Analyzer

As most of its readers know, *Technology Review* is a project of the Alumni Association of M.I.T. — an effort to help our readers (including many M.I.T. alumni) understand the issues which motivate the fields which the Institute and its graduates serve throughout the world. A corollary of this is the fact that the senior staff officer of the Alumni Association (his title is executive vice president) has responsibilities as our publisher.

Rarely if ever has a new appointee in the role had professional experience in advertising, circulation, or communications; but the issues of magazine management have always been embraced warmly and the magazine itself quickly become a major passion of its publisher. That was true without qualification in the case of James A. Champy, who relinquished the role of publisher at the end of 1978 to return from M.I.T. to private industry; the *Review* has never had a stronger advocate and its editors a more sympathetic overseer.

The same interest in publishing is already apparent in Mr. Champy's successor, James A. Hester, Jr., whose background is in the field of public administration and systems analysis. Mr. Hester studied aeronautics and astronautics at M.I.T. with the Class of 1965 and continued for a Master's degree in 1966. After three years of professional work in that field, a growing interest in modeling and simulation techniques applied to social problems led him back to M.I.T. for a doctorate in urban systems and planning; since 1970 he has worked on policy analysis and planning in New York City housing and health services and — most recently — the Kaiser Permanente Medical Care Program in Southern California.

All this raises the interesting (and unanswered) question of whether quantitative modeling and analysis appropriate for managing such large systems as cities and medical institutions can bring order to the chaos which seems traditional in editorial enterprises. — *J.M.*

Capping the Arms Race

I find it alarming that you give credence to the evaluation of the MX weapon in the report of M.I.T.'s Program in Science and Technology for International Security (P.S.T.I.S.) in your article "Technology Frays the Thread of Peace" *(Trend of Affairs, June/July, 1978)*. The report's statement that "new technology improvements will create threats to national security of the U.S. and U.S.S.R. more rapidly than the present international political climate permits the conclusion of agreements constraining weapons" does not represent a proper statement of the situation. Insofar as the U.S. security is concerned, our reliance on assured destruction as a major deterrent has already eroded our security since the Soviet Union has never accepted our assured destruction philosophy in structuring their strategic forces. Our strategic forces have become vulnerable to attack by Soviet missile forces because the Soviet Union has built strategic forces designed to attack and destroy military targets, not to deter a U.S. attack on Soviet cities.

Because of the apparent differences in strategic philosophies, the U.S. has been placed at a military disadvantage which could be exploited. The Soviet Union could attack or threaten to attack our military targets while the U.S. response can only threaten their population centers or industrial recovery targets. This U.S. response is not credible when the Soviet Union has more than adequate strategic reserves, after a disarming strike on the U.S., to destroy our cities after they have reduced our capabilities by an attack on our strategic forces. That the Soviet Union has focussed their attack on our strategic forces indicates their intent to neutralize the U.S. as a credible defender of our international commitments to Europe and in other parts of the world.

The MX system will enable the U.S. to have a survivable strategic force which would be capable of destroying Soviet targets after an attack by a large percentage of the Soviet strategic forces. The U.S. would then have as equal or greater capability after such an attack. This is a stabilizing situation since there would be no advantage to the Soviet Union to attack. Contrary to the P.S.T.I.S. claims, the new MX/multiple aim point system provides the only potential means for capping the arms race.

John E. Stevens
Lynnfield, Mass.

Refueling Reactors

It is not clear what radioactive materials are spoken of when David Salisbury indicates that Mr. Jefferson of Sandia says "... 200 vital shipments of radioactive material must reach each nuclear reactor annually" in his column "Restrictions Derail the Nuclear Express" *(August/ September, 1978)*. He also says that "commercial reactors cannot operate for longer than six months without refueling."

Having been directly involved in the nuclear fuel supply for four large commercial reactors, including approximately 100 fuel shipments during the past five years, I find these statements seem incorrect. The fuel supply for a single refueling is normally accommodated on five or six legal weight trucks. Further, this single refueling provides sufficient fuel for the reactor to operate for twelve to eighteen months before another is needed.

Sanford Hellman
Lynchburg, Va.

Trade Offs of Fuel Consumption

I couldn't agree more heartily with the view expressed by John Boshier in his excellent article *("Can We Save Energy by Taxing It?" August/September, 1978)* that an energy policy which raises the price of energy will, in the long run, serve the goal of fuel conservation. I disagree, however, with his conclusion that tax incentives, aimed at stimulating investments in energy-efficient machinery, would work against the long-term goal of fuel conservation because the result would be "to substitute energy-consuming machinery for labor, increasing productivity and reducing employment." This conclusion is based on a goal to decrease total fuel consumption with time regardless of the economy's output of goods and services or of its competitive standing relative to its

(Letters continued on p. 8)

ALUMNI TRAVEL PROGRAM 1979-80

This special travel program, to some of the most interesting areas in the world, has been especially designed for alumni of Harvard, Yale, Princeton, M.I.T., Cornell, Dartmouth, Univ. of Pennsylvania and certain other distinguished universities and for members of their families. It is consciously planned for persons who normally prefer to travel independently, and covers lands and regions where such persons will find it advantageous to travel with a group.

The itineraries are designed for the intelligent traveler, and offer an in- depth view of historic places, ancient civilizations, archeological sites and artistic treasures, as well as interesting and far-flung cultures of the present day and spectacular scenery from virtually the four corners of the globe. The programs are, however, also planned to incorporate generous amounts of leisure time and to avoid unnecessary regimentation so as to preserve as much as possible the freedom of individual travel, while utilizing the savings and the practical convenience which group travel can offer.

Considerable savings have been obtained by using special reduced fares offered by the world's leading scheduled airlines, fares which are generally available only to groups or in conjunction with a qualified tour and which offer savings of as much as $500 and more over normal air fares. In addition, special group rates have been obtained from hotels and sightseeing companies. By combining these savings with a careful selection of the finest available hotels and facilities, it is possible to offer travel arrangements of the highest standard at moderate and economical cost.

AEGEAN ADVENTURE — 23 Days: The archeological treasures of classical antiquity in Greece and Asia Minor and the islands of the Aegean, with visits to Constantinople (Istanbul), Troy, Pergamum, Smyrna (Izmir), Sardis, Ephesus, Epidauros, Mycenae, Olympia, Delphi and Athens, as well as a cruise through the Aegean to the islands of Crete, Santorini, Mykonos, Rhodes and Patmos. Departures April through October.

MEDITERRANEAN ODYSSEY — 22 Days: An adventure into realms of antiquity in the western Mediterranean, with the ruins of Carthage and the Roman cities of Africa in what is now Tunisia, the splendid Greek temples of Sicily (including the famed "Valley of the Temples" at Agrigento and the ruins of Syracuse, the city of Archimedes), the remarkable Norman churches of Palermo, dating from the age of William the Conqueror, and the fortress cities of the Crusader Knights of St. John on the island of Malta. Departures March through October.

VALLEY OF THE NILE — 17 Days: A detailed view of one of the greatest civilizations the world has ever known, the civilization of ancient Egypt along the valley of the Nile. The itinerary includes Cairo, the pyramids of Giza, Sakkara, Dashur and Meidum, Memphis, Abydos, Dendera, the great temples and monuments of Luxor, including the Valley of the Kings and the tomb of Tutankhamun, and a cruise on the Nile of Upper Egypt to visit Esna, Edfu, Kom Ombo and Aswan, as well as the great monumental temples of Abu Simbel near the border of the Sudan. Departures January through December.

THE ORIENT — 29 Days: A magnificent survey of the Orient, including the exotic temples and palaces of Bangkok and the ruins of ancient Ayudhya, the great metropolis of Singapore, the enchanted island of Bali with its unique artistic heritage, the famed port of Hong Kong on the border of Red China, and a comprehensive visit to Japan which places special emphasis on the cultural treasures and the tranquil beauty of classical Japan at the historic city of Kyoto and at Nara, Uji, Kamakura and Nikko, as well as the mountain scenery of the Fuji-Hakone National Park and the modern capital at Tokyo. Optional visits are available to the ancient temples of central Java and the art treasures of the National Palace Museum in Taiwan. Departures March through November.

BEYOND THE JAVA SEA — 32 Days: A remarkable journey through the tropics of the Far East, from the port of Manila in the Philippines to the tea plantations and ancient civilizations of Ceylon, the Malay Peninsula, the Batak tribes of Sumatra, the ancient temple ruins of Java, the fabled island of Bali, headhunter villages in the jungle of Borneo, and the unforgettable beauty of the lights of Hong Kong. Departures January through November.

MOGHUL ADVENTURE — 30 Days: The great historic and cultural heritage of India, combined with the splendor of ancient Persia and a journey into the high Himalayas in the remote mountain kingdom of Nepal: imposing Moghul forts, ancient temples, lavish palaces, the teeming banks of the Ganges, snow-capped mountains, picturesque cities and villages, and the Taj Mahal, culminating with the famous mosques of Isfahan and the 5th century B.C. palace of Darius and Xerxes at Persepolis. Departures January through November.

SOUTH AMERICA — 28 Days: An unusually comprehensive journey through the vast continent of South America, from the Inca ruins and colonial heritage of the western coast, amid the towering snow-capped Andes, to the great Iguassu Falls and the South Atlantic beaches of Brazil. The itinerary includes the colonial cities of Bogota, Quito and Lima, the great Inca centers of Cuzco and Machu Picchu, La Paz and Lake Titicaca, the magnificent Argentine Lake District at Bariloche, Buenos Aires, the Iguassu Falls, Sao Paulo, Brasilia and Rio de Janeiro. Departures January through November.

THE SOUTH PACIFIC — 28 Days: An exceptional tour of Australia and New Zealand, with Maori villages, boiling geysers, fiords and snow-capped mountains, ski plane flights, jet boat rides, sheep ranches, penguins, the real Australian "Outback," historic convict settlements, and the Great Barrier Reef. Visiting Auckland, the "Glowworm Grotto" at Waitomo, Rotorua, the Southern Alps at Mt. Cook, Queenstown, Te Anau, Milford Sound and Christchurch in New Zealand, and Canberra, Tasmania, Melbourne, Alice Springs, Cairns and Sydney in Australia. Optional extensions available to Fiji and Tahiti. Departures January through November.

EAST AFRICA — 21 Days: A distinctive game-viewing and photographic safari to the wilds of Africa, covering some of the greatest wildlife areas in the world. From the semi-desert of Kenya's Northern Frontier region and the vast game-filled plains of the south to the lakes of the Great Rift Valley and the snow- capped peak of Kilimanjaro, the itinerary includes Nairobi, the Nairobi National Park, Treetops, Meru National Park, Samburu Game Reserve, the Mt. Kenya Safari Club, Lake Nakuru National Park, Lake Naivasha, an extended stay in the great Masai-Mara Reserve, Amboseli National Park and Tsavo National Park, with optional visits to the coast at Mombasa and Lamu. Departures January through December.

Prices range from $2,295 to $3,575 from U.S. points of departure. Fully descriptive brochures are available on each tour, setting forth the itinerary in detail with departure dates, relevant costs, hotels used, and other information. For full details contact:

ALUMNI FLIGHTS ABROAD

White Plains Plaza, Dept. TR11, One North Broadway, White Plains, N.Y. 10601

(Continued from p. 6)
trading partners. Thus, the substitution of fuel-consuming machinery for labor, the increase in productivity, and the reduction in employment are viewed by the author as policy failure, rather than as a successful restructuring of the economy to provide more goods and services per unit of fuel consumed. The difference between the amount of fuel consumed by such an economy and the minimum amount of fuel it could consume by shifting towards greater employment and less machinery must be weighed against the benefits that would accrue from greater productivity and enhanced trade standing.

The current economic climate clearly calls for the integration of a fuel conservation strategy that would substantially decrease the balance of payments deficit with an economic strategy aimed at fighting inflation and restoring a sound currency by attempting, among other things, to reverse the decline in productivity experienced in recent years.
Sherif S. Fam
Waltham, Mass.

Re-Refining: A Tardy Meeting of Law and Technology

The Bartlesville Energy Technology Center of the Department of Energy (formerly the Bureau of Mines and E.R.D.A., respectively) has written and published more data related to used lubricating oil re-refining (*see "Used Oil: Collection, Recycling, and Disposal" by Will A. Irwin, August/September, 1978, pp. 54-61)* during the past seven years than any other organization in the world.

In addition to our large basic research program, we recently have patented a new process technology which requires no acid and we are in the process of deciding how best to transfer this technology to the private sector. We hope to either build a plant on a cost-sharing basis with a partner from private eneterprise or retrofit our process into existing re-refining facilities. We also plan to continue basic research in such areas as by-product utilization, industrial oil reclaiming, quantitation of lubricating oil availability, and advantages and disadvantages of re-refining versus burning used oil.
M. L. Whisman
D. W. Brinkman
Bartlesville, Ok.

Mr. Whisman has been project leader and Dr. Brinkman is acting project leader for waste oil recycling at the Bartlesville Energy Technology Center.

Straw-Man Against Nuclear Power

Dr. Najarian's article should be treated with caution. His conclusions are faulty; several reviews have disclosed that his and Dr. Mancuso's data do not imply higher cancer rates related to worker exposure. The "doubling-dose" argument suggested in Dr. Najarian's article was first used by John Gofman, and it, too, has been shown to be contrived. Dr. Najarian uses a lot of "ifs." Some of his hypotheses are very unlikely, but he nevertheless moves quickly to state their consequences.

It is well known that some people are trying to parlay the low-level exposure issue into a lever against nuclear power. Dr. Najarian appears to be another such opportunist, using straw men such as the need for "overwhelming evidence" to disprove the possibility of cancers from worker exposure.
A. David Rossin
Chicago, Ill.

The writer is System Nuclear Research Engineer with Commonwealth Edison. Dr. Najarian responds:

The subheadline "Either the new data are faulty . . ." was written by me and indicated the prudent reservations that I have at this point about the significance of the new studies. I had hoped that I made my own doubts clear in the report. If Dr. Mancuso is correct in his analysis, then the next ten years should bear him out as new information accumulates. But readers should remember that it was only when Dr. Mancuso's and my studies appeared that the need to study these workers was appreciated. If we are wrong, then we may all rejoice in the assurance of a healthy nuclear future free from fossil fuels pollution.

What Naval Workers' Families May Not Know

There are an estimated 500 workers from my home town employed by the Portsmouth Naval Shipyard. Among these are my father and several dozen close relatives and friends. I also worked there for a brief period during the summer of 1974. I therefore have very good reasons to be concerned about the findings on the health effects of low-level radiation at the Shipyard reported by Dr. Thomas Najarian in "The Controversy Over the Health Effects of Radiation" *(November, 1978, pp. 74–82)*.

On the other hand, as a young student of science, I believe it is important that the study be presented and analyzed in a thoroughly scientific manner. It is thus very disturbing to me that this study is being used as definitive proof by certain groups of the "dangers of nuclear energy."

Work on nuclear-powered submarines first began in 1959. We can assume that Shipyard workers did not become significantly exposed to radiation until several years later. As the article quite clearly pointed out, there is a long germination period, anywhere from eight to ten years, between the exposure to radiation and the outbreak of latent cancer, and Dr. Najarian agrees that it is still too early to see the effects on workers except for the few people who did the earliest work in the industry. Yet Dr. Najarian reports that the cancer death rate for "radiation workers" has ranged from 43 per cent in the "early years" to 37 per cent for 1976–77.

One might then conclude that those who died of cancer in the "early years" could not have died as a result of exposure to radiation, and that the cancer death rate among Shipyard workers has decreased since work has been under way in nuclear-related areas. I believe that the latency factor is an important one which Dr. Najarian has failed to thoroughly consider in his study.

My second specific criticism concerns the method by which nuclear and nonnuclear workers were classified. In *Technology Review,* Dr. Najarian states that his "control" and "experimental" groups were determined on the basis of the perceptions and recollections of the deceaseds' next-of-kin. Being the son of a Shipyard worker, I am skeptical. I was unaware for all these 20 years of whether my father did or did not work in a nuclear-related area, or whether he wore a radiation film badge; and so were others in my immediate family. I only know that he spoke every evening about the nuclear-powered submarines he was working on. I finally discovered last spring that he does not work in "nuclear-related" areas and does not use a film badge. My notions were wrong all these years, and I must assume that many other kin are equally unaware of the true facts on this matter. When confronted with questions about radiation exposure and the knowledge that one's relative died of cancer, next-of-kin may naturally assume, "yes, he worked in nuclear." If just 20 next-of-kin in Dr. Najarian's study inaccurately reported that their deceased relatives (cancer-related) worked in the nuclear area, the percentage of cancer deaths amongst nuclear workers drops to 28.6. It

is indeed unfortunate that the Navy denied Dr. Najarian access to the radiation records of deceased workers.

Throughout the article, Dr. Najarian made reference to work performed by T. F. Mancuso on low-level radiation hazards at the Hanford nuclear complex. But no fewer than 15 reviews, including those by Britain's National Radiological Protection Board and the U.S. Nuclear Regulatory Commission, have rejected these results.

I do not pretend to be an expert in radiological sciences, and I believe Dr. Najarian's study was a very honest effort. I could see where Dr. Najarian would perhaps quite justifiably claim that the nuclear industry is just trying to save its skin. As he admits, Dr. Najarian's study is still incomplete, and it is unfortunate that many have taken his report to be scientific gospel on low-level radiation. Further study is clearly warranted.

Donald A. Dube
Cambridge, Mass.

Dr. Najarian responds:

The 43 per cent of cancer deaths among nuclear workers in the "early years" compared to only 37 per cent in 1976–77 does not necessarily suggest a declining death rate. The 43 per cent figure was in fact based on only three deaths out of seven; we were unable to contact the next-of-kin of many workers who died 15 and more years ago. Furthermore, since my article was written I have seen radiation records which indicated that some Portsmouth workers in fact had done nuclear work prior to 1959, presumably at other nuclear facilities.

Mr. Dube is quite correct, of course, in his assessment of limitations of knowledge of next-of-kin, and I plan a more complete study and publication based on official radiation records as they become available.

The 15 reviews that "have rejected" the Mancuso study have not in fact rejected the findings of the study (a statistically significant increase in cancer of the pancreas and multiple myeloma which was related to radiation exposure) but rather disagree that the findings "prove" the relationship solely to radiation exposure. Many of the reviewers suggest that the extra deaths might have been caused by some other carcinogen associated with higher radiation exposure, though no specific carcinogen has been thus implicated in the Hanford population. In assessing the Mancuso study, J. A. Reissland of the National Radiological Protection Board of England states that Mancuso's work is important because it is "essentially the only large-scale study which has been reported of the effects of occupationally permitted levels of exposure to ionizing radiation."

Persuading by Threat

Kenneth E. Boulding is Director of the Institute of Behavioral Science and Professor of Economics at the University of Colorado at Boulder. He is a regular contributor to Technology Review.

Threats are a prevalent lever in the moral economy — that domain where human activities are devoted to changing the world for the better. They are a form of communications, explicit or implicit, from a threatener to a threatened party stating that if the threatened party does not do something which the threatener wants, the threatener will do something which the threatened party does not want. But this tactic to realign the balance of "public goods" can often provoke greater disorders.

This "threat system" is a very small part of nonhuman life, though we do find it in the establishment of pecking orders in birds, in the growls and snarls of many mammals, and in signals which protect against potential predators — the rattle of the rattlesnake, and the black and yellow of the wasp. But their importance in society should not be exaggerated. By far the largest amount of human activity involves neither conflict nor threat. Production, exchange, courtesy, family life and so on, while they may have a certain underlying background of threat, on the whole operate more within the realms of what I call the exchange system and the integrative system.

Carrot and the Stick

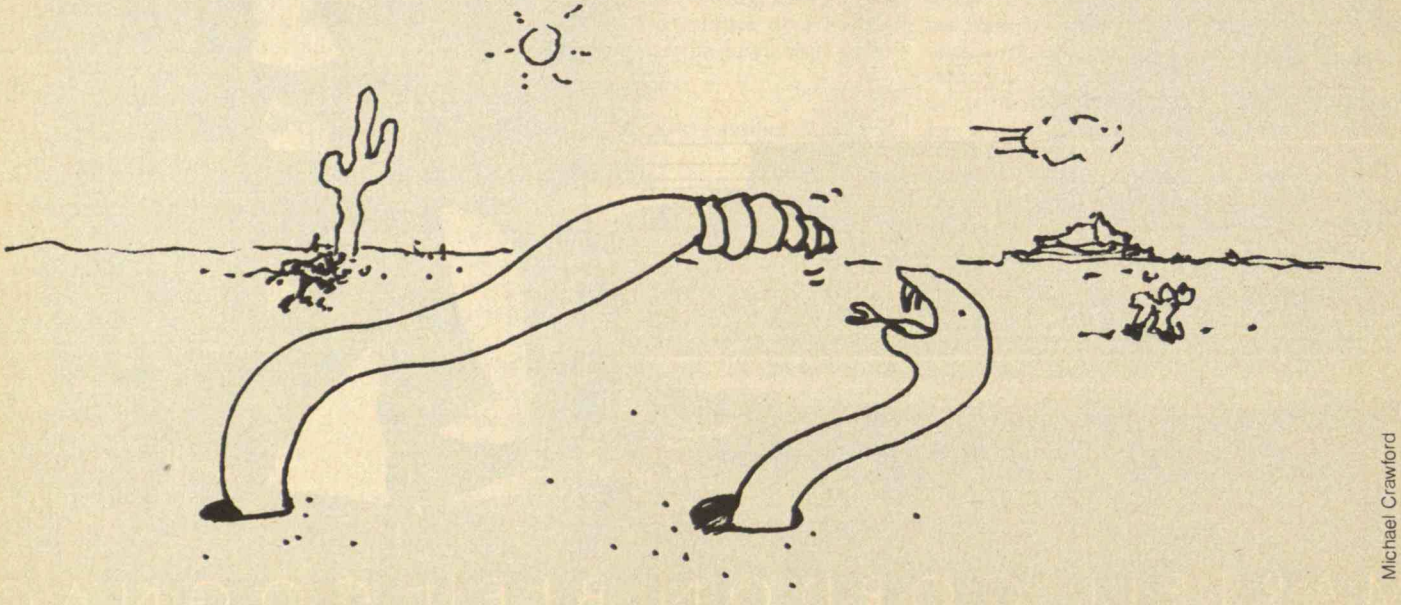
The role of threat in the moral economy is legitimated in varying degrees. At one end of the scale, we have the ethic of science which renounces the use of threat altogether except perhaps the threat of expulsion from the scientific community for behavior — like falsifying data — which violates its ethos. Apart from this exception, the scientific community is guided by the basic principle that people should be persuaded by evidence and not by threat. Like all ethical principles, there are exceptions in practice. Professors have been known to threaten students with poor or failing grades if they persist in opinions which the professor regards as personally threatening. At the level of peers, however, threat is virtually taboo. One of the great myths of our time is that the scientist will be delighted when his theories are proved wrong by somebody else. If we fall short of this in practice, the idea at least is never abandoned in principle.

The political sovereign, whether the national state, the feudal baron, the war lord, or the guerrilla band, rules the other end of the scale. In the interchange of political sovereigns, which we might call the international system, the threat relationship is supreme. Perhaps as a consequence, the international system has always been a major producer of human misery. At the present time indeed it is by far the most pathological of all segments of the world social system, and the only one that threatens us with possibly irretrievable disaster. Why we go on supporting it to the tune of $3 to 4 hundred billion a year, with resources that are desperately needed for human betterment, only its perverse dynamics can explain. No more spectacular example of the tragedy of the commons can be found than unilateral national defense.

In the internal relations of the political sovereign with its own citizens, the threat relationship is legitimated and constitutionalized, modified by integrative structures and even by a little exchange in terms of public goods, but it is still dominant. We pay our taxes because of threat, even though we may recognize the threat as legitimate and accept it in a threat-submission relationship.

The diminution of the use of threat and the ritualization of political conflict have strong claims to be an important indicator of political maturity. This maturation is a process of a slow and painful learning in which strong and irregular fluctuations occur over large parts of the world. The 20th century certainly scores low on political maturity!

Somewhere between these extremes is a large territory where the role of threat is ambiguous. In the family it leads into the pathologies of spouse beating and child abuse and though threat may have declined in legitimacy along with the traditional authoritarian family with its belief of "spare the rod and spoil the child," one sometimes has an uneasy feeling it may not have declined much in incidence.



Michael Crawford

Bluff, Lies, and Escalations

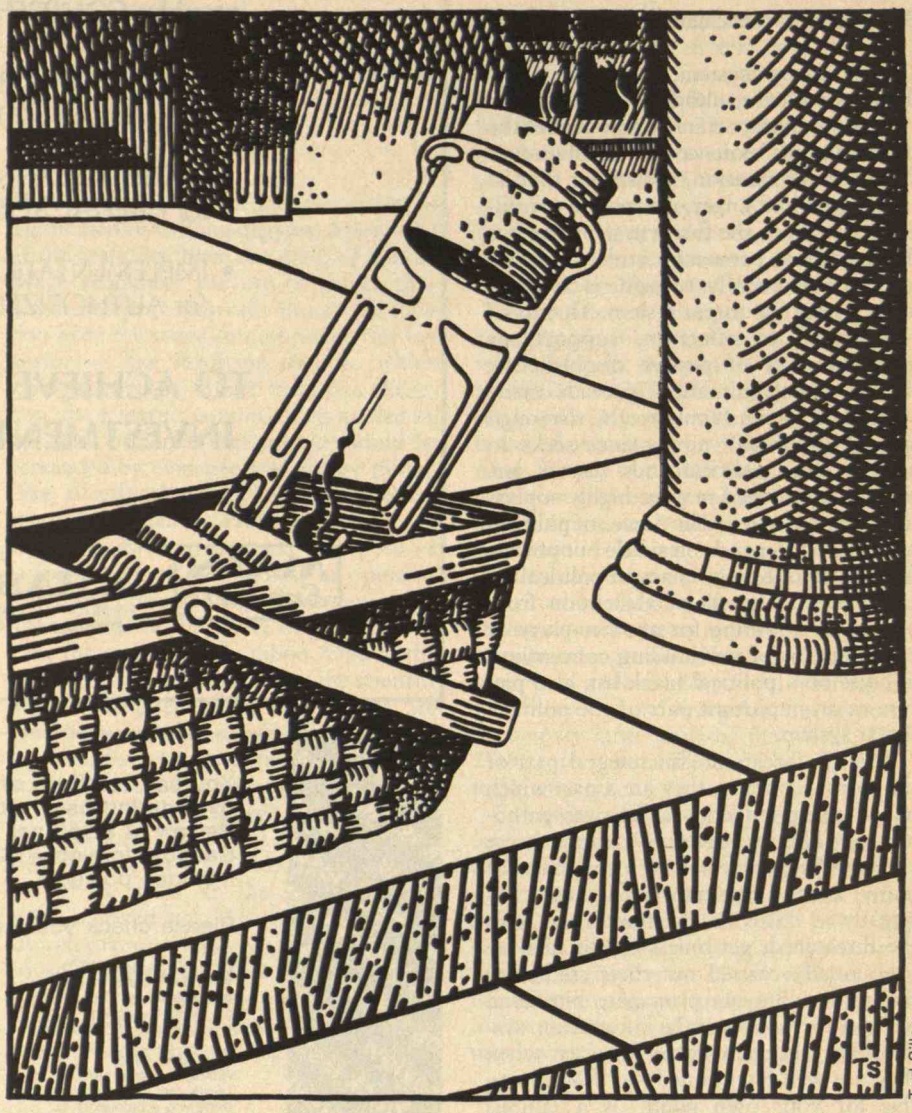
Threat, in any system, is not the same thing as violence, although the threat of violence is an important component of the threat system. Violence that involves predation, extermination, sadism, or that issues from blind anger, can not be considered relevant to the threat system, for it is divorced from persuasive intent. Nonviolence, paradoxically enough, is a major actor within the threat system. Threats of withdrawal of affection, support, or grants, threats of passive disobedience, threats of delegitimation, pervade many systems from the family to the sovereign state. "Gandhian" nonviolence seeks to achieve clear political ends just as terrorism, and indeed may be highly sophisticated and explicit. The power of political nonviolence depends on subtle but powerful threats to the legitimacy of political establishment. Threats of abstention from voting, or of voting for another party or candidate, or of not holding conventions in cities on a political black list, also picture as an important part of the political threat system.

Though threats are an integral part of the moral economy, they are a part which has a strong tendency to become pathological. Threat produces counterthreat and we find ourselves in arms races of many kinds. Enacted threats are frequently as costly to the threatener as to the threatened, yet unless the threats are occasionally carried out their credibility diminishes. Threats propagate bluff and lies and corruption of the information system. They beget malevolence even when they are well-intentioned — "I am doing this for your own good" is a famous theory of punishment which frequently rings hollow to both the punisher and the punished.

In the dislocated dynamics of threat things tend to go from bad to worse rather than from bad to better, but how threat can be made less pathological should clearly be one of the major research interests of normative science. As an essential element of social systems, threat cannot be eliminated. One could almost visualize a whole new discipline built around the study of threat, with a profession of practitioners engaged in diminishing its evil consequences, but this seems a long way off. □

Research and Development: Government's "Battered Child"

Robert C. Cowen, Science Editor of the Christian Science Monitor, *is former President of the National Association of Science Writers and is a regular contributor to the* Review. *He holds S.B. and S.M. degrees in meteorology from M.I.T.*



Ted Sillars

The partnership between the American research and development communities and their government is in trouble. You have only to listen to the imagery with which research administrators and organizations describe that once beneficial relationship.

Speaking for the academic community, for example, M.I.T. President Jerome Wiesner has compared university research to "a battered child" — unloved, underfed, and needlessly restricted by a hostile government. In recent ads of Gould Electric Company industrial research and development is portrayed as a weary Statue of Liberty, one eye blackened, being strangled by a noose of excessive government regulation — sentiments typical of others in industry.

This is no sudden crisis. It has evolved out of a decade and a half of inflation and budget tightening, of conflicting efforts to control risks to public health and the environment, and for universities, especially, of an antipathy in Congress to basic research.

Indicators of Inventive Decline

Roy A. Anderson, board chairman and chief executive officer of the Lockheed Corp., summarized much of industry's concern in an address last fall before the Wings Club in New York. "The key point," he said, "is that today our inventive thrust seems to be diminishing and our technological lead threatened." He finds indications of this in lagging U.S. productivity and diminished funds:

☐ Today the rate of increase in U.S. productivity is below that of any of the other major industrial countries. In fact, the first half of 1978 saw an actual decline.

☐ Total U.S. research and development spending dropped from 3 per cent of the Gross National Product in 1963 to 2.2 per cent in 1977.

☐ Basic research in industry has been declining since 1966 when, in 1972 dollars, it peaked at $800 million. In 1977, it declined to $550 million in 1972 dollars.

To this list, one should add industry's perception that excessive regulation for health or environmental purposes is stifling innovation — Gould's specific complaint. Chemical and drug companies feel especially sapped. Their efforts are diverted by "defensive" research to ensure that new products won't run afoul of existing or yet-to-be created regulations. It's a complaint that the Carter administration recognizes, as Gilbert S. Omenn of the President's Office of Science and Technology Policy made clear at a meeting of the Manufacturing Chemists Association in November. The United States, he said, needs to find a more rational balance between idealistic desires for a "totally pristine environment and unrealistic health goals" and pressures for hastily "abandoning reasonable goals and efforts to give ourselves a quick shot of economic growth."

Skeptics may doubt the severity of the purported drop in inventiveness when one widely used indicator — decline in patent applications — is proving faulty. *Science* magazine reports that patents aren't as useful to industry as they once were, particularly in a hot field such as electronics where companies may prefer not to patent and give their technological lead away. Instead, they are "going underground," potting components in resins and using other measures to hide the essence of new circuitry. Taking all indicators into account — including patents, level of re-

search investment, and trends in that investment — a recent National Science Foundation study concluded that the United States is maintaining its technological leadership.

Findings such as these soften industry's alarm somewhat. But they don't dull the point that a spokesman such as Roy Anderson is making, for he is concerned with on-going trends and with the deteriorating of the research and development–government relationship.

A Dog's Breakfast of Methods

Trends in federal funding for universities are also an important part of the picture. President Carter had promised something like 5 per cent real growth beyond inflation to amend for years of stagnation in basic research funding. But inflation and congressional tinkering have largely frustrated that hope for the new fiscal year that began October 1.

An assessment by the American Association for the Advancement of Science (A.A.A.S.) shows an overall research and development budget of $29.6 billion, up 8.8 per cent from last year. But, with at least 7 per cent inflation, few agencies can show increases in real dollar terms. Moreover those scrubby gains have been lopsided. Congress, ever-favorable to health-related research, boosted the National Institutes of Health (N.I.H.) research funds and compensated by holding the National Science Foundation, for example, to little more than the rate of inflation. All told, the A.A.A.S. says, basic research is getting about $3.75 billion. That's an overall increase of about 3 per cent over the president's budget recommendation because of the N.I.H. boost, but insignificant for basic research in other areas.

While this disappoints academics who thought that the long night of low funding might end, it is not the core of their discontent. William D. Carey, A.A.A.S. executive officer and a veteran observer of the science-government partnership, explains: "There has been an unwise and unthinking tendency to look solely at the curve of federal research and development funding as a kind of Dow Jones clue to the health of science. Other factors are just as important to the vitality and productivity of research and development. If budget dollars are to be scarce, government can help the utilization of the research and development it has funded by overhauling its static patent policies. It can make existing research dollars stretch farther by simplifying rather than adding to the dog's breakfast of methods, procedures, and controls that are now imposed on university research at such formidable costs to productivity. Government can apply the brakes to the profusion of regulations that retard risk taking and innovation in industrial research and development. In doing these things, government would reduce inflationary pressure and free budget dollars that are drawn off from research into defensive administration. The view from this quarter is that genuine progress in these directions would go a long way toward making austere research and development budgets more acceptable."

This is precisely Dr. Wiesner's point. Government has abandoned its nurturing role in university research, which has been a source of national strength. Instead, he says, it is treating universities like "purveyors of products, to be held accountable by the standards of trade and commerce."

As a specific example of this kind of regulation, he cites the new National Science Foundation rule that no faculty member can be paid more than the civil service ceiling of $47,500 and receive N.S.F. support — a congressionally imposed restriction. "What this means," he says, "is that Congress is limiting the reimbursability of salaries of the best faculty, the stars, the Nobel Prize winners, those people who make institutions great. Universities will have to make up the difference, starting with an already substantial impact, and that's only the beginning."

Dr. Wiesner also cites an Office of Management and Budget (O.M.B.) proposed set of guidelines for tighter budget control of research grants. He calls it crippling interference in university administration. Among other things, universities would have to ensure that payments to graduate students from a research grant are given only for direct research work, not for education. The net result would be more complicated bookkeeping (with attendant costs) and a more restrictive university environment.

At the annual meeting of university research administrators in Washington last fall, Dr. Wiesner was painting a dramatic picture of a conviction he and his audience shared — that the "federal-academic relationship . . . is foundering."

Courting a New Relationship

However, the situation is not all dark. For one thing, both university and industrial research have a friend in the White House. President Carter continues to emphasize his recognition of the importance of research. He told a news conference in November, "I have directed in the prepa ration of the 1980 fiscal year budget that basic research and research and development in general should not be reduced as a percentage of the total federal budget." Additionally, presidential science advisor Frank Press has built a working relationship with the Office of Management and Budget (O.M.B.). A joint memo he and Bowman Cutter of the much maligned O.M.B. sent the president a year ago stressed the need to upgrade instrumentation, a major problem for universities whose equipment is suffering from obsolescence and the high cost of replacement.

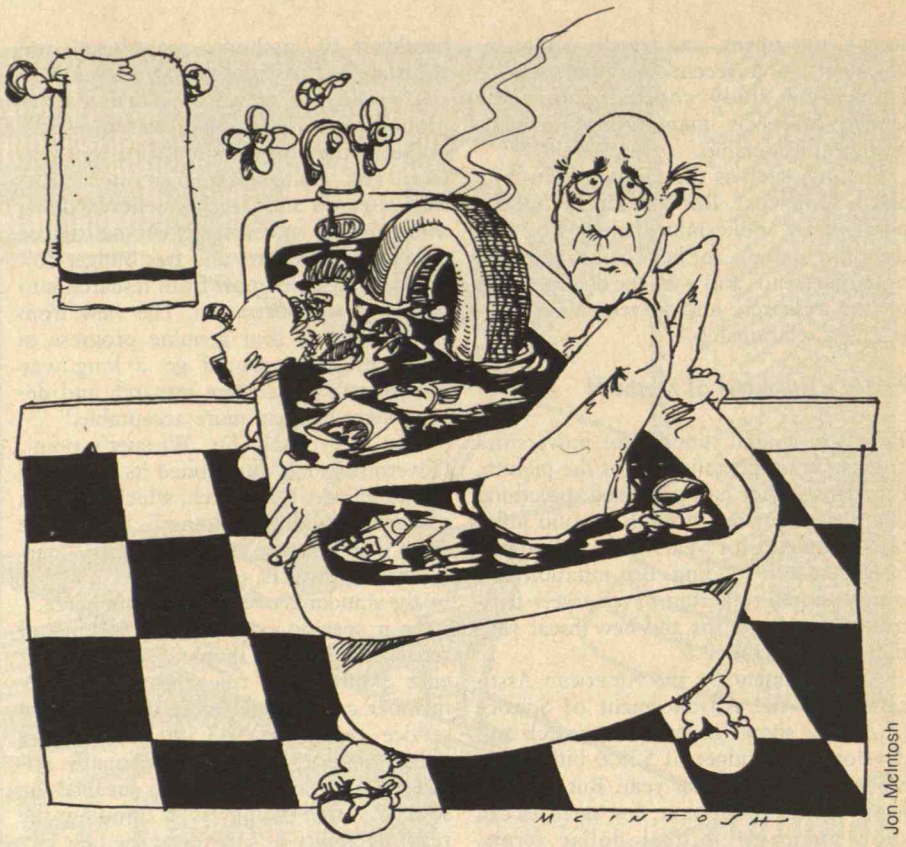
Much of the hostility, such as it is, lies with Congress, whose members are sensitive to the grassroots "tax revolt" and not generally sympathetic to research needs. If the federal-academic relationship is to be renewed, it is here that the wooing must start. The favor given N.I.H. research funds makes the point. Congress was prepared by a lobbying operation of the health science community early in the year. Briefing congressional staffs privately and speaking at public hearings, this group argued for long-term support for fundamental studies in health research, not crash programs to tackle the "disease of the month." Academics in other fields, and university administrators, need to cultivate the new Congress this way.

As for industry, its research and development complaints are now being reviewed by a task force under Secretary of Commerce Juanita Kreps and her Assistant Secretary for Science and Technology Jordan Baruch which should report its recommendations in the spring. With modest expectations for the impact of such a study, it should at least give prominence and coherence to industry's problems.

Evolving a new government-research partnership will take time, patience, and much creative diplomacy. But there remains some comfort in thinking that the process now may be underway. □

Troubled Waters

Steven J. Marcus is Director of the Residuals Management Group at Energy Resources Company in Cambridge. He holds a Ph.D. in Engineering from Harvard University.



Jon McIntosh

General Jack D. Ripper would drink no water straight from the tap. Only superdistilled, absolutely pure H_2O would maintain his "precious bodily fluids" against the "insidious Communist" plot of fluoridation. What better, more fundamental way to erode a society, thought this caricatured archpatriot from Stanley Kubrick's "Dr. Strangelove," than to subtly contaminate its water supplies?

America's drinking water, it turns out, is contaminated — not necessarily by fluorine (whose addition is meant to achieve some useful effect) — but by a wide variety of organic chemicals, quite a few of which are known or suspected carcinogens. The source of these "additives," moreover, is not some foreign conspirator. They are the routine byproducts of good old American industry and of the water-purification processes which supposedly guard our health in the first place.

About one year ago, the U.S. Environmental Protection Agency (E.P.A.) officially proposed regulations intended to be "the start of the first large-scale effort in history to deal with organic chemical contaminants in drinking water." In partial fulfillment of the Safe Drinking Water Act of 1974, they had two distinct provisions: a required treatment process — granular activated carbon (GAC) — to abate the spectrum of industrially-derived organics; and a specific standard (100 parts per billion) for the unintended byproducts of chlorination — namely, chloroform and the rest of its family of trihalomethanes (THM).

The E.P.A. had come a long way from its contradictory revelations of 1974, when it announced that diverse organic chemicals, including carcinogens, were chronically present in the water supplies of most American cities. But it also said please not to worry — "we don't feel at this time that there's any need for general alarm. It is a problem," said the E.P.A., "that needs to be looked into."

So they looked into it, quite carefully, over the next three years. And after several large-scale pollutant-monitoring surveys, consultations of a great variety of experts, lawsuits initiated by environmentalists, and enlarged interpretations of E.P.A.'s legal responsibilities under the Safe Drinking Water Act, they changed their tune. Acknowledging that the "low levels" of carcinogens in drinking water supplies had not been *proven* to cause cancer in local populations, the E.P.A. nevertheless concluded, from the available toxicological and epidemiological data, that these low levels "pose a significant health risk . . . as a result of long-term exposure" and that "such exposure may increase the risk of human cancer and other chronic effects."

Citing the preventive nature of the Act and the prevailing opinion that there is no "safe" level for a carcinogen, the E.P.A. proposed its organics regulations under the following straightforward logic: if a chemical causes cancer, then reducing the amount of the chemical in drinking water will reduce the threat of cancer.

A Recalcitrant Water Works

The water works industry did not respond warmly. It had never before been regulated on a national scale, and it had prided itself on the rarely challenged belief that America's drinking water is among the best in the world simply because massive chlorination keeps it free of waterborne disease organisms. The likelihood that chemical contaminants (a "modern" development) could pose threats that were at least as serious as the more "classical" biological problems seemed to have caught the industry unawares. It looked foolish, backward, and incompetent. Its first reaction to the proposed regulations — in the grand tradition of polluters and negligent pollution controllers — was to deny the problem outright, to impugn the motives of those who take it seriously, and to call for more study.

The American Water Works Association (A.W.W.A.) — representing most of the country's major water suppliers — asserted that the regulations "do not have a sound scientific basis," that they are "of no known health significance," and that the cost of reducing these alleged threats would be exorbitant. The E.P.A.'s cost estimates, claimed the A.W.W.A, were "ridiculously low." The whole unpleasant situation was blamed on certain "publicity conscious people" and "highly vocal pressure groups" whose irrational, Chicken-Little fears had somehow convinced an entire federal agency that the sky was falling.

On a more conciliatory note, the

A.W.W.A. conceded "there is cause for concern about organics in drinking water" and that "questions have been raised that demand answers." But all these "questions," dealing with health, cost, and technical feasibility, would have to be studied long and hard prior to regulation. Even though convincing data were already available in each of these areas, the A.W.W.A. nevertheless dismissed them as "speculation."

The Coalition for Safe Drinking Water (an ad hoc organization of water companies formed in response to the proposed regulations) spent less time on polemics and more on developing its own data. It considered the E.P.A.'s estimated costs for GAC treatment, for example, to be "off-the-wall," so it hired an engineering consulting firm to derive other estimates (the capital cost of which turned out to be twice as high as for the E.P.A. estimate). Similarly, it computed its own THM standard to be 300 p.p.b. (as opposed to E.P.A.'s 100 p.p.b.). This was derived from the work of its consultant, Francis Roe (notorious among environmentalists for his belief that cancer "is probably one of nature's many ways of eliminating sexually effete individuals"), who claimed to have determined a specific "no-effect" level for chloroform's carcinogenesis. The coalition's 300 p.p.b. just happens to be a shade less than the country's highest recorded concentration (311 p.p.b. in Miami), and so it would affect very few cities.

"We are not an obdurate industry," says coalition lawyer George Pendygraft, "and we don't say don't ever do something. We say that we shouldn't take action until we have decent data."

Safety Still Dubious

The E.P.A. disagrees about the decency of the data, as do the environmentalists who influenced the proposed regulations. Action is already long overdue, they believe, and these seemingly draconian measures are only the beginning. More research and experience will indicate not whether they are appropriate, but how much more should be done.

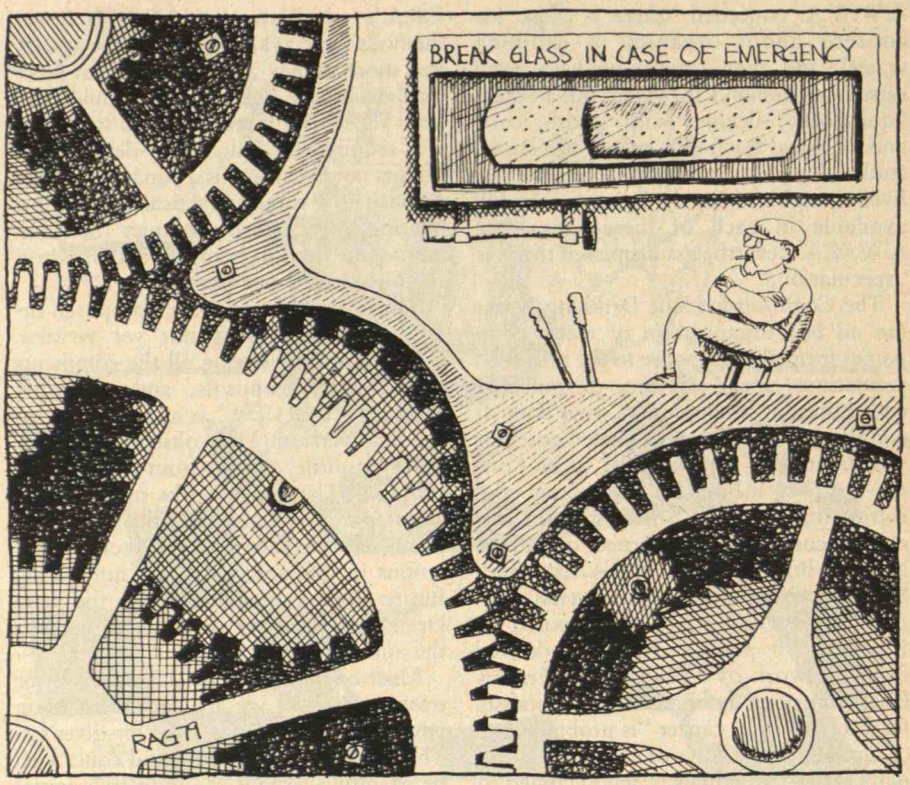
The E.P.A.'s explicit policy, supported by the National Cancer Institute and other federal health organizations, is one of "limiting human exposure to carcinogens to the maximum extent feasible." Its 100 p.p.b. standard on THM, for example, was not chosen because it is "safe," according to Dr. Ervin Bellack of the Office of Drinking Water, but because it is technically attainable and consistent with E.P.A.'s administrative ability. If better methods were available, and if the agency had more money and personnel for technical assistance, the standard would have been yet stricter. Similarly, GAC treatment was required for industrially-derived pollutants not because it is a panacea, but because it is a single, practical method for abating thousands of organics (thus obviating the need to regulate, and monitor, these chemicals one-by-one).

The final draft of E.P.A.'s proposed organics regulations is not yet written. E.P.A. is still reviewing all the comments and counter-proposals, and will only promise "early 1979" as a target date for the final version. Most observers predict, however, little change from the original proposal. The water works professionals are preparing to fight this outcome on two fronts: by challenging the specific regulations in the courts; and by influencing future laws (amendments to the Safe Drinking Water Act) in order to weaken the authority at its source.

Most of us cannot go out and get our own water, and we are dependent upon what the water works industry gives us. This water is not the best, and could well be harmful. Perhaps the industry's initial reluctance will be overcome, and enlightened regulatory policies will prevail. But one wonders about the possible erosion of our society (conspiratorial theories notwithstanding) when even our drinking water — so vital to life and well-being — can no longer be considered safe, and when the nominal guardians of its purity fight tooth-and-nail against improvements. □

A Bright Future for Complexity

Warren Bennis has been watching people and their organizations ever since studying for his doctorate in economics and social science at M.I.T. He's now living in Aspen, Colo., commuting to Geneva and Los Angeles as a visiting professor, and planning a new career after dividing the last 25 years between teaching and administering. He is the past immediate president of the University of Cincinnati (1971-77.)



Richard A. Goldberg

Alfred North Whitehead cautioned us wisely: "Seek simplicity and then distrust it." Trouble is that too many — especially those responsible for solving our social problems who come up with non-solutions — seek simplicity and then forget to distrust it. Like one of the more popular "solutions": the best way to solve a problem is to just throw more money at it.

It's a familiar story. We all know people who try to "do good," but somehow, unexpectedly, things turn out worse than before. Some illustrations: the latest miracle drug has unexpected side effects; lawmakers enact bills and then discover consequences never anticipated and which undermine their original purposes; and sunshine laws prohibiting closed meetings lead more and more to cliques meeting privately beforehand to agree on actions subsequently revealed at the "public meeting."

The problems of our world are too complex for any one person to get his head around, for any organization or institution to absorb let alone deal with. The fact is that there are too many predicaments, too many grievances, the many institutions under attack; and too few institutions trying to understand them. There are too many ironies, polarities, dichotomies, dualities, ambivalences, paradoxes, contradictions, confusions, contraries, complexities, and messes. Especially messes.

Vanquishing the Villain

"It's the mess in which we live," said Henry Ford in a recent issue of *Fortune*, referring specifically to the regulatory profusion hampering the automotive industry: the Clean Air Act, the Energy Conservation Act, the Motor Vehicle Information and Cost Savings Act, the National Traffic and Motor Vehicle Safety Act.

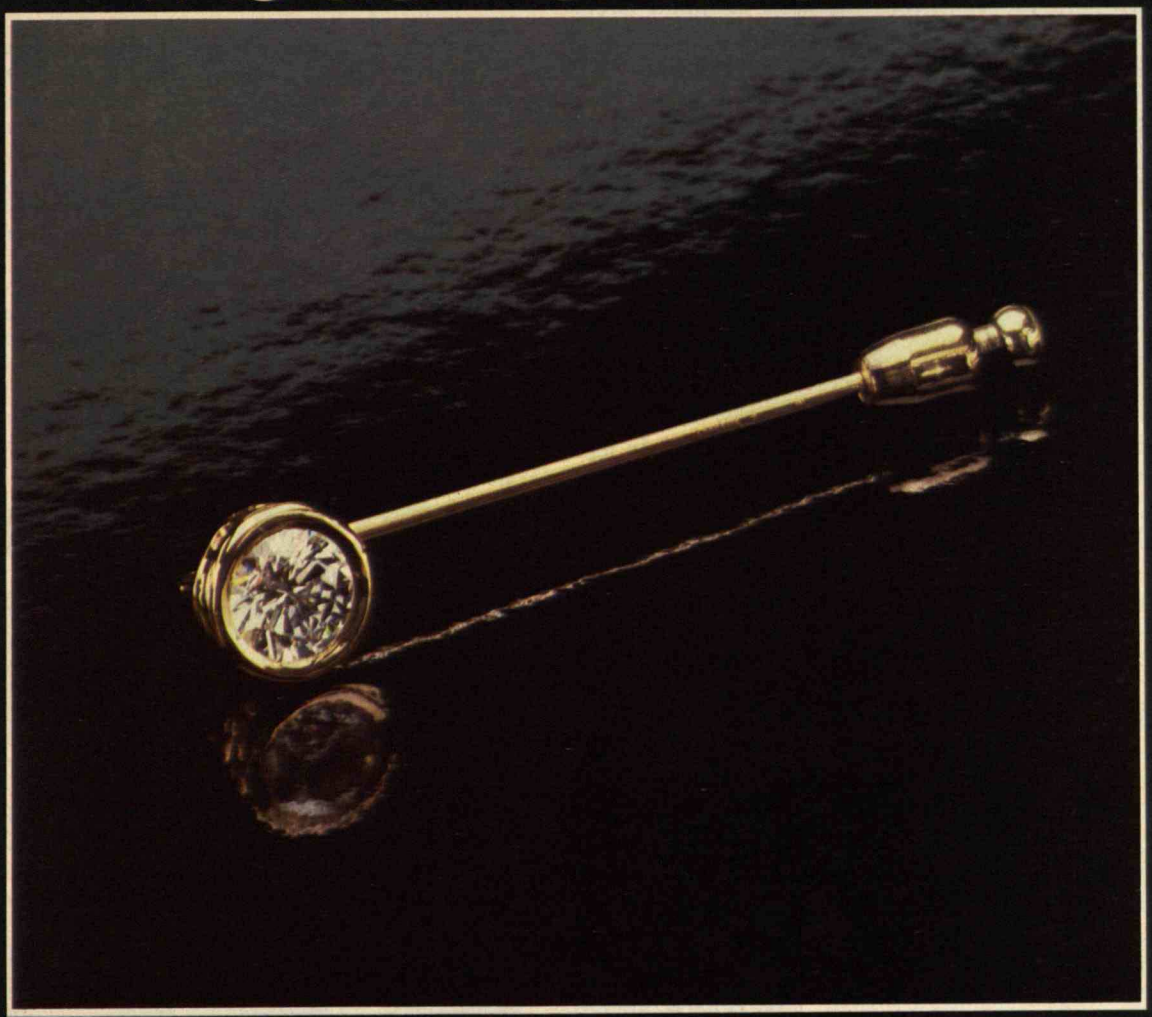
Trouble is, as my "mess list" shows (see box), most everyone seems to be involved in a different and "favored" mess, with each of us feeling like a lonely Hercules cleaning out his messy astrodome littered by an unknown villain. For the automotive industry, compliance to federal regulations is seen as a "punitive speed-up," and the major villains are a wayward Congress, a neglectful White House, and overzealous regulators. The solution seems simple: deregulation, fire the regulators, or both.

For the incongruous duo of Lewis Lapham, editor of *Harper*'s, and Billy Martin, the ex-manager of the New York Yankees, the *media* are the villains. Lapham, writing in *Harper*'s, February, 1978, says: "It is the ubiquitousness and thus the apparent omniscience of the media that sustains the general impression of impotence." Martin, when asked to account for the Yankees' winning streak of 18 out of 20 games after his departure, quickly replied: "The newspaper strike has made the difference. There aren't any reporters about stirring up garbage and writing what one player says of another." The simple solutions here range from censorship to more subtle forms of restrictions on a free press.

When New York City suffered its second major blackout in July of 1977, the process of fingering the villains began long before the power was restored. A Consolidated Edison spokesman blamed the outage on an "act of God." Mayor Beame indicted Con Ed for "gross negligence." Three different government reports blame Con Ed's top management. No one at Con Ed is still trying to pin the rap on God. In their final report Con Ed has conceded to place the underlying cause closer to Earth. They now blame "legislative, regulatory, and environmental opposition."

A final example of "simplicity without distrust" comes from the mounting current of opinion that such individuals who bring illness on themselves — e.g. lung cancer, cyrrhosis of the liver — should be ineligible for health benefits or should pay a much higher premium since they seem to jack up everyone else's premiums and tax bills. It seems an understandable conclusion; it is hard to conceive of a more apt expression of our fundamental belief in individual responsibility. Of course, the solution would entail a new bureaucracy composed of a battalion of newly annointed "health judges" who would be

The diamond solitaire.



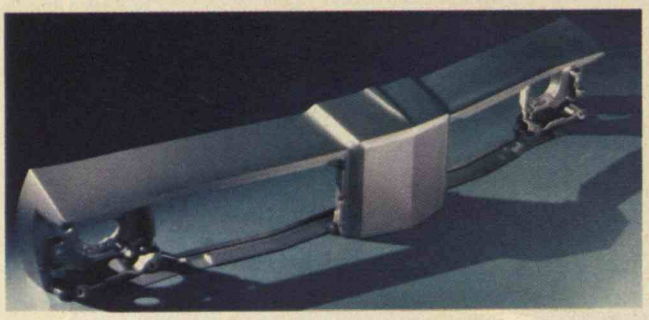
A rare gift.

A 1⅛ carat diamond. Set simply and elegantly.
To sparkle on its own. Of lasting value,
because diamonds of about 1 carat and up are rare.
(The one shown here is worth about $5,950.)
The diamond solitaire.
It is the gift that makes a rare and beautiful
moment last a lifetime.

A diamond is forever.

The 1⅛ carat diamond shown is enlarged for detail.
Prices may change substantially due to differences in diamond quality and market conditions. De Beers.

SMC, or sheet molding compound, is a stiff, lightweight plastic composite consisting of resin, powdered filler, and randomly oriented chopped fibers. With the continuing trend toward lighter automotive materials, SMC is becoming a promising replacement for steel.

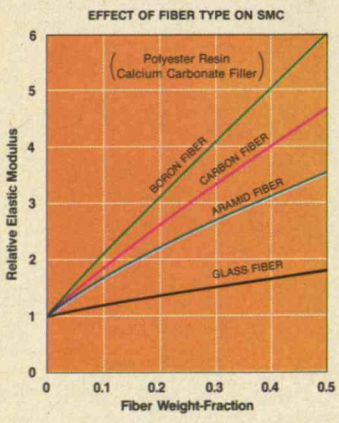


But can this plastic compete with metal? In light duty it can. In fact, thanks to redesigning, some SMC parts outrival their steel counterparts.

However, for structural application where stiffness is paramount, redesigning the part may not be enough. That's why engineers here at the General Motors Research Laboratories addressed the problem of "redesigning" the material, too.

The challenge was an imposing one: For a given use, find what ratio of which resins, fillers, and fibers provides the best mix for minimizing weight without adversely affecting stiffness and cost. And do it analytically. (Blending and testing would take forever.)

So our engineers modeled the resin-filler-fiber system. Then using micromechanics theories for calculating the stiffness of resin + filler and of resin + fiber, they devised a mathematical procedure that predicts the stiffness of any blend of all three components.



This unique analytical tool has two potent capabilities. It enables designers to determine an SMC composition that meets structural and cost goals — in other words, to tailor the material to the need. And it aids our engineers in exploring the cost-effectiveness of lighter, stiffer components such as glass microsphere fillers and carbon fibers.

Mathematical analysis: the best way of designing a material having endless combinations of ingredients.

We currently have openings for Ph.D.s in engineering or the physical, mathematical, or biomedical sciences. If interested, please send your resume to: GMR Personnel, Dept. 216. An Equal Opportunity Employer.

We've set the stage for SMC combos to perform better.

General Motors Research Laboratories
Warren, Michigan 48090

assigned to every hospital in the nation, at least as many lawyers to staff the appeal process, and at least twice the number of lobbyists.

Cure-Messes and Cause-Messes

Doing something about "health criminals" provides an example that makes it virtually impossible to disagree with the notion that the chief cause of problems is solutions. While that aphorism is itself too simplistic, it illustrates the fact that we have amplified our problems into two messes: the "cure-mess" and the "cause-mess."

The former is created by attempts to ameliorate, if not eradicate, a cargo of past injustices. For the Ford Motor Company (and it is fairly representative of the industry) the cure-mess has led to recalling 1.5 million Pintos and the threat of more government regulation. The Ford case also highlights the truism that cornering the villain tends to block the view of what led to the dreaded cure-mess in the first place.

Which brings us to the cause-mess, which singularly obsesses consumer advocates like Ralph Nader. Ever since the mounting evidence has come to light that Pinto models built during the early years are dangerously susceptible to fires and explosions if struck from the rear, they have been advocating ever-stronger federal controls — and similarly losing track of what caused it in the first place.

Confusion about messes causes not only sloppy cures and dumb "search and destroy" antics for villains but, worse, a chilling silence among too many citizens as the cure/cause mess arguments are flung back and forth like leaky beanbags filled with novacaine until the public weal is reduced to numbed indifference.

Perennial Predicaments

Simplistic solutions are often forerunners of leaders who thrive on them. A number of observers now predict the possibility of a dictatorship as the fissures of our society deepen. The forecasts of fascist leadership concern me far less than its preconditions: our collective incapacity to tolerate ambiguity in the face of enormously complicated problems — an incapacity which too often leads to a hasty search for instant relief.

I'm more concerned that the automotive industry blames "the mess in which we live" solely on governmental regulation and not on faulty engineering which, when ignored, at its very least brings about the crude mechanism of legislative action and backlash. A recent report of the U.S. Commission on Civil Rights was inspired to literally "redress" the effects of racism caused by years of stereotyping women and minorities in the media. Fair enough. But listen to one recommendation for the "handling" of Native Americans: "Accurate portrayal . . . requires that the American Indian be presented as a brave defender of his homeland and of a way of life as good and free and reverent as the life dreamed of by the immigrants who swarmed to these Eastern shores." Now *that* doesn't correct an egregious sin of the past; it repeats it: Indians are simply to be re-stereotyped.

What we're faced with today are a confusing and overlapping set of predicaments which may have no "final solution" — unless they're allowed to languish until legislative action comes down on us like an anvil. A massive system failure often triggers a legislative reaction that is too extreme, un-nuanced, and often ineffective. Lamenting about cure-messes instead of diagnosing the problem carefully beforehand will, inevitably, bring more cure messes to lament about.

A Bright Future for Complexity

I think an argument can be made for the importance of complexity — if we learn to use it to our advantage.

Predicaments represent one of the most basic characteristics of all successful modern societies — perhaps all living systems: they keep alive alternatives that are antithetical to that moment's dominant emphasis. Later one alternative may submerge for a recess while another pole surfaces. "Without contraries," Blake wrote, "there is no progression." When predicaments cease, one must be especially vigilant, for it may be that a significant option has been expunged.

The poet, Luis Borges, must have had that in mind when he quoted from "a certain Chinese encyclopedia," which completely upends our present system of categories. He writes: ". . . animals are divided into: (a) belonging to the Emperor, (b) embalmed, (c) tame, (d) sucking pigs, (e) sirens, (f) fabulous, (g) stray dogs, (h) included in the present classification, (i) frenzied, (j) innumerable, (k) drawn with a very fine camelhair brush, (1) et cetera, (m) having just broken the water pitcher, (n) that from a long way off look like flies."

Borges' "Chinese encyclopedia" makes a shambles of our patterned responses, like a really good joke or poem or gifted mentor. It complicates our lives as well by challenging us to start thinking about things that, if not new, are certainly different.

There's little reason to expect simpler times in our future. Leave those hopes to cowboy movies and nostalgia buffs. Before we continue "throwing money" at problems or generally thrashing about, it might be wise to learn a bit more about the complex root of our predicaments; then we might learn a bit more about why one thing works and another doesn't.

"I predict a bright future for complexity," said a character in an E. B. White short story written over 50 years ago. "Have you ever considered how complicated things can get, what with one thing always leading to another?" □

Forty-five Messes: A Chain Letter

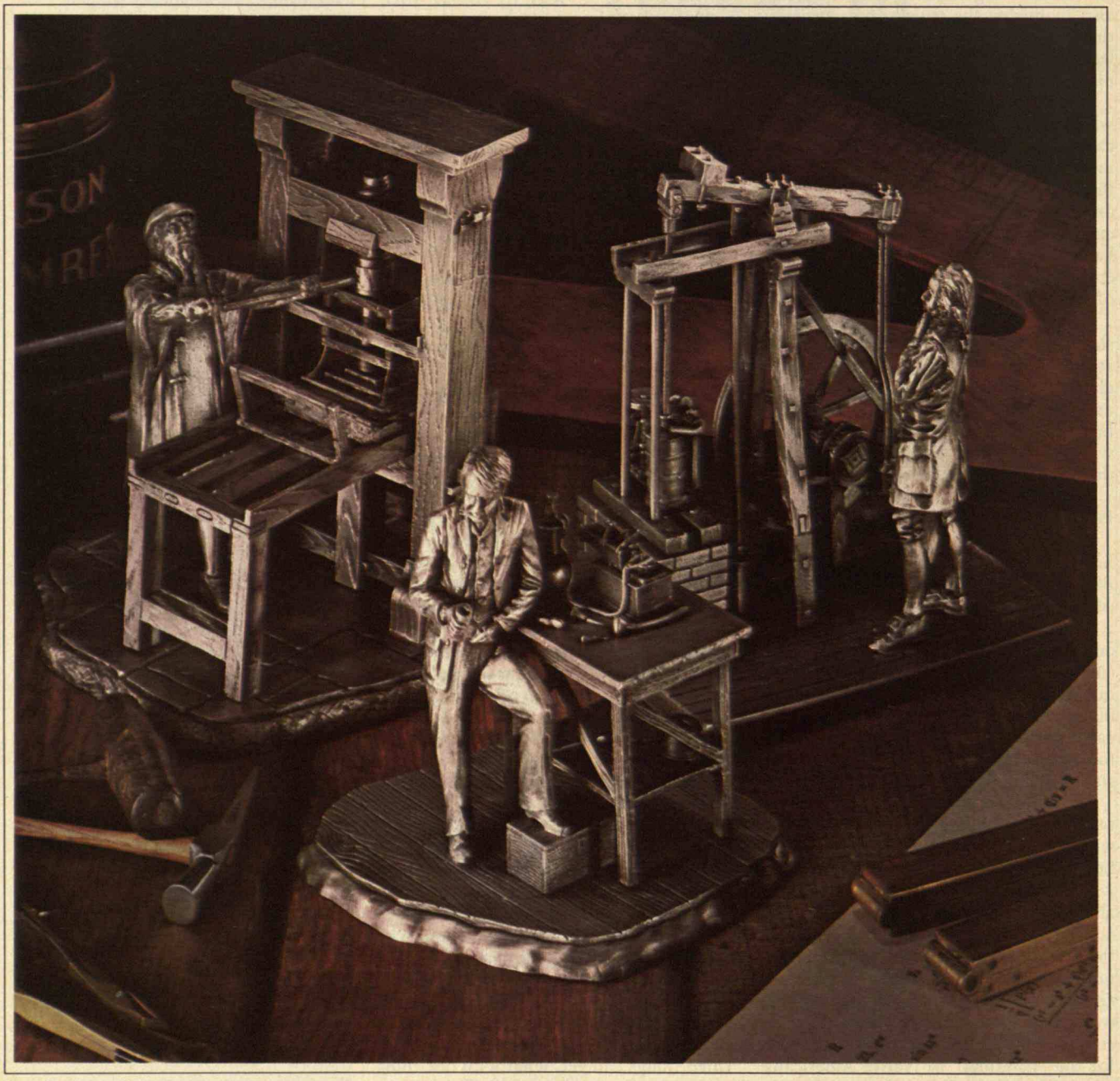
Check your favorite mess, add two more to the top of the list, and send to your five worst enemies. This will assure the proliferation of predicaments and guarantee a bright future for complexity. It will also get this off your desk and on to somebody else's. (Messes listed in alphabetical order.)

Accelerating change
Anemic and/or inept leaders
Balkanization of U.S. society; i.e., the end of consensus
Big government, big media, big unions, big universities, big everything
Bureaucracy
Continuing crowding and hunger
Corporate scandals and other criminal actions by authorities
Crime
Crisis of public education
Death of the "free market"
Dehumanization
Eclipse of community
End of the "melting pot" hypothesis
Failure of "bigness"
Failure of experts to agree
Failure of Keynesean economics to deal with inflation
Fragmentation — of life, work, ideas, solutions, world views, families
Governmental regulation and costs of compliance
Hedonism and/or meanspiritedness of the people
Hypocrisy of corporate America
Inflation
Legal and illegal "cover-ups"
Literacy
Media
Moral/spiritual decline
New concepts of growth
New concepts of no-growth
Nuclear proliferation
People cannot realize their potential, or "people are no damned good"
Poverty
Privacy and secrecy
Restrictions of freedom
Revolution of rising aspirations by the heretofore "disenfranchised"
Reluctance to provide adequate financing for equalizing the above
Scarcity
Shift toward conservatism
Shift toward a "planned state"; i.e., socialism
Taxpayers' revolts
Technology
Third World pressure for equity and "new international economic order"
Treason of professionals; i.e., more concern with themselves than clients
Twilight of the hydrocarbon era
Unemployment
Unwillingness to meet the Third and Fourth Worlds' basic needs
Welfare and debt
Women's movement and its effects
Work has become soulless

To Commemorate Its 75th Anniversary, *The Deutsches Museum* presents

The Inventions that Shaped the Modern World

An official collection of ten superbly crafted pewter sculptures... honoring the genius of mankind



From left: Johannes Gutenberg ca. 1395-1468, James Watt 1736-1819, Thomas Alva Edison 1847-1931.

Sculptures shown approximately actual size.

A single, limited edition.

Available solely by subscription application.

Limit: One collection per subscriber.

Subscription deadline: February 28, 1979.

This year marks the 75th Anniversary of The Deutsches Museum—the largest museum of science and technology in the world. To observe the occasion in an appropriately unique and memorable way, the Directors of the Museum have authorized the creation of an unprecedented commemorative issue—honoring:

"THE INVENTIONS THAT SHAPED THE MODERN WORLD"

This official commemoration will comprise ten superbly crafted pewter sculptures—each re-creating an historic "moment of invention." In all, they will pay homage to ten of the most important landmarks in the history of modern science—depicting the inventions themselves and the men of genius credited with their creation. They include:

THE PRINTING PRESS
Johannes Gutenberg

THE TELESCOPE
Galileo Galilei

THE STEAM ENGINE
James Watt

THE CAMERA
Louis Daguerre

THE X-RAY
Wilhelm Roentgen

THE PHONOGRAPH
Thomas Alva Edison

THE WIRELESS TELEGRAPH
Guglielmo Marconi

THE TELEPHONE
Alexander Graham Bell

THE AUTOMOBILE
Gottlieb Daimler

THE AIRPLANE
The Wright Brothers

Each of the sculptures crafted for the collection will be a wholly *original work of art*—created exclusively for this 75th Anniversary celebration. Moreover, the collection will reflect the most scrupulous standards of *scholarship*, for each sculpture will be fully authenticated for scientific accuracy by the Museum. Indeed, the beauty and detail that distinguish each of the ten sculptures—the costumes . . . the facial expressions . . . and especially the detail lavished upon the actual inventions themselves—pay tribute to the highest criteria of science and art.

So vividly detailed, in fact, are these ten extraordinary sculptures that you will actually be able to see the first crude type form developed by Gutenberg for his printing press . . . the innovative separate condenser that proved so vital to the success of James Watt's steam engine . . . virtually every pipe and bolt of the historic internal combustion engine that was destined to establish Gottlieb Daimler as the father of the automobile. . . .

The world's foremost creator of commemorative issues

To ensure the creation of a commemorative issue that will retain its power and significance for generations to come, The Deutsches Museum has enlisted the skills and talents of an organization whose name has become synonymous with many of today's most prestigious commemoratives: The Franklin Mint. Hence "The Inventions that Shaped the Modern World" will be the direct creation of the very artists who are universally recognized as the contemporary world's foremost inheritors of the great Renaissance tradition of medallic sculpture.

And when the sculptors of The Franklin Mint have completed their commission, each of these exquisitely crafted pewter sculptures will be individually hand-finished—to bring out every feature and detail . . . the subtlest nuances of the artist's work . . . as well as the rich, gleaming luster of the sculptured metal itself.

The assurance of lasting rarity

Furthermore, "The Inventions that Shaped the Modern World" will be created in only one, extremely limited edition—to be issued solely in honor of the 75th Anniversary of The Deutsches Museum, and made available only by subscription application.

In addition, there will be a further limit of just one collection per subscriber. Consequently, the entire edition will exactly equal the precise number of valid applications entered before the subscription rolls close.

To certify the official nature of the collection, the base of each sculpture will bear the emblem of The Deutsches Museum and identify the creator of the invention depicted. Moreover, a Certificate of Authenticity bearing the signature of The Director-General of the Museum—attesting to the limits of the edition—will accompany the sculptures. Subscribers will also receive authoritative background literature on the evolution of each invention and its enduring impact upon mankind.

An heirloom collection of universal significance

"The Inventions that Shaped the Modern World" has been expressly conceived as a commemorative of truly *international* significance — fully reflective of the overwhelming universal importance of the subject it honors.

For collectors who recognize and appreciate the beauty of sculptured art . . . for parents who seek to imbue their children with a keener understanding of the world they inhabit, and a deeper awareness of man's potential for greatness . . . indeed, for everyone who is enthralled by the story of civilization itself . . . there can be few acquisitions more inspiring, more enlightening, more lastingly rewarding.

Subscription deadline: February 28, 1979

Following the absolute closing date of this single edition, "The Inventions that Shaped the Modern World" will never be offered again in the United States. Please note that you need send *no money now* to enter your subscription for the collection. However, your application can be accepted only if it is postmarked no later than the final subscription deadline of *February 28th.*

SUBSCRIPTION APPLICATION

The Inventions that Shaped the Modern World

Valid only if postmarked by February 28, 1979.
Limit: One collection per subscriber.

The Franklin Mint
Franklin Center, Pa. 19091

Please enter my subscription for "The Inventions that Shaped the Modern World"—an official collection of ten superbly crafted pewter sculptures to be issued by The Deutsches Museum on the occasion of its 75th Anniversary.

The sculptures will be issued at the rate of one every three months, and the issue price of $90.* each will be billed to me in three equal monthly installments of $30.* I need send no money now, and will be billed for the initial installment prior to shipment of my first sculpture.

**Plus my state sales tax*

Signature _____

Name _____
PLEASE PRINT CLEARLY

Address _____

City _____

State _____ Zip _____

ALL APPLICATIONS ARE SUBJECT TO ACCEPTANCE.

Toward Radical Changes in Steelmaking

by Julian Szekely

There is no shortage of promising (if exotic) new technologies to assure the future strength of the U.S. steel industry.

Its steel industry is an important component of every industrialized society. Steel is a strategic material, and it plays an essential role in many industrial activities, including transportation, construction, industrial machinery and consumer durables. The steel industry is a major employer of labor and a significant consumer of energy, an important contributor to the gross national product in every developed country. In the case of the United States, a strong domestic steel industry capable of supplying most domestic needs is a requirement for economic well-being.

But it is an industry in trouble. Since 1974 there has been a sharp drop in world demand for steel, sharp increases in the cost of energy and raw materials for steelmaking, and a corresponding worldwide reduction in the profitability of steel production.

Steel producers in the United States have been particularly hard hit by these developments, and the industry today is faced with very serious problems. It has lost its competitiveness in export markets, and it is seriously challenged by imported steel in its domestic field. Production has been reduced and workers laid off, frequently in areas of already high unemployment.

During the past five years the steel industry has been one of the least profitable of U.S. manufacturing operations (*see table p. 27*). Profits were only 3.6 per cent of sales in 1976, and many U.S. steel corporations reported substantial losses for 1977.

Only one fully integrated, modern steel mill has been built in the U.S. since World War II. New technology as well as more efficient integration must be applied widely if the U.S. steel industry is to recover its leadership in domestic and foreign markets. (Photo: coils of sheet steel await shipment from Bethlehem Steel's Burns Harbor (Ind.) Plant)

Steel production has had well-documented adverse effects on the environment, and its necessity to control pollution has presented the industry with mandated capital expenditures for pollution abatement and with higher energy consumption. These needs have been ill-timed: capital has been hard and expensive to obtain, and increased energy consumption has exacerbated the problems caused by rising fuel costs. Nor are these problems behind the industry: at a time when investors have been understandably reluctant to provide the capital for necessary modernization and expansion, pollution control will add at least 15 per cent to the cost of new facilities in the future.

Current Steelmaking Technology: How It Works

The purpose of this article is to explore possible solutions to the problems faced by the U.S. steel industry, with emphasis on the role that could be played by technology. To set the stage for the discussion of this main issue, we must digress briefly to describe existing steelmaking technology in the United States and the problems that are inherent in the current mode of operation. There are five stages in conventional steel processing (*see pp. 28-29*) by which raw materials are converted to finished steel products:

- ☐ Raw materials preparation and cokemaking
- ☐ Ironmaking
- ☐ Steelmaking
- ☐ Casting and primary rolling
- ☐ Finishing.

It is customary to term the first four stages as the "primary end" and the last stage as the "finishing end." Consider each of these in turn.

Raw materials preparation processes convert the iron ores and the coking coal into forms suitable for ironmaking.

The ores, essentially iron oxides containing some impurities, must be agglomerated into particles at least roughly the size of small marbles before they are introduced into blast furnaces. This is done either in pelletizing units (usually located at the mine site) or in sinterplants in which mixtures of fine ore particles, limestone, and other materials are made to undergo partial fusion.

The coke, which serves both as a reducing agent and as a fuel in ironmaking, is manufactured in coke ovens using metallurgical coal as a raw material. Finely ground coal is heated in the absence of air to temperatures at which volatile matter, moisture, and

some of the sulfur compounds are driven off. The result is metallurgical coke; the volatiles, known as coke oven gas, are also a valuable fuel.

Most *ironmaking* is done in iron blast furnaces, which are in essence tall vertical shafts up to 30 meters high and 10 to 15 meters in diameter. Iron in ore, sinter, or pellets, flux (limestone), and metallurgical coke are charged at the top, while preheated air is blown into the system at the bottom. There is partial combustion of the coke, and the oxygen and minerals are removed from the iron ores, reducing them to metallic iron, during their descent through the furnace. The main products are molten iron (containing carbon, silicon, manganese, sulfur, and phosphorus), molten slag, and blast furnace offgas. Typically, a single such blast furnace produces some 1,000 to 10,000 tons of molten iron per day.

An alternative to the blast furnace, especially suitable for small-scale operations and where oil or natural gas are readily available, is provided by so-called *"direct-reduction"* processes. These are carried out in vertical-shaft furnaces in which iron ore pellets are contacted with an ascending mixture of reducing gas in a counterflow arrangement. The product of direct reduction units is solid sponge iron which has to be melted and refined in electric arc furnaces to obtain steel. Typical direct reduction units produce some 1,000 tons per day. (At present less than 5 per cent of the world's total ironmaking capacity is based on direct reduction.)

Steelmaking is the process of purifying the metal from the blast furnace or obtained by direct reduction — recycled steel scrap may also be used — by selectively oxidizing such impurities as carbon, silicon, manganese, sulfur, and phosphorus.

The *open-hearth* steelmaking process involves the treatment of hot metal and scrap in a shallow reverbatory furnace which is heated by burning oil or natural gas. The impurities are oxidized and withdrawn as slag and offgas. This is oldest of the currently used technologies, but it is rapidly fading in significance due to its high energy and labor requirements.

The dominant steelmaking operation at present is the *basic oxygen* process, in which molten iron and scrap are introduced into a pear-shaped vessel and then a supersonic oxygen jet is blown onto the bath surface. The oxygen reacts with the impurities to create slag and offgas, and the refining is completed in less than 25 minutes, in contrast to several hours in the open hearth process. A variant of the basic oxygen process is the Q–BOP operation, which involves blowing oxygen and a coolant through the bottom of the vessel.

Steel is also made in *electric furnaces,* which are attractive because they can accept charges ranging from 100 per cent scrap to 100 per cent molten hot metal. Such a furnace consists of a cylindrical shell with a dished bottom and covered by a removable roof through which graphite electrodes are inserted. The arc struck between these electrodes and the metal charge provides the thermal energy needed to melt the charge, and the impurities are oxidized by an injected oxygen stream.

Casting and primary rolling are carried out immediately after the steelmaking is completed. In conventional mills, the steel is formed into ingots which are processed into blooms or slabs at a later time in the *primary* (rolling) mills. If continuous casting (a much more energy-efficient operation) is used, slabs and billets are produced directly as the new steel emerges from the furnace. The slabs and blocks (called billets and blooms) thus produced are converted to the final products in *finishing* mills, where these intermediate products are brought to the proper temperature in reheating furnaces and are then rolled in several stages (hot and cold strip mills, bar mills, and the like) into the finished shapes.

A typical integrated steelplant, comprising all the processes described above, is a very complex operation. There are some 40 plants of this type in the U.S., ranging in capacity from about one to eight million tons per year of finished product. Total U.S. finished steel production is now about 100 million tons per year. The average cost of producing one ton of steel in a U.S. plant is about $350, of which energy and raw materials account for 45 per cent, labor for 35 to 45 per cent, and capital service charges (including depreciation) 6 to 10 per cent. To make one ton of steel in the U.S. requires 36 Gigajoules (34 million B.t.u.) of energy and 8.2 man-hours of labor. The book value of such a plant is about $120 per ton of annual output, but the replacement cost is about $1,200 per ton.

A detailed breakdown of these figures *(chart, page 33)* shows that most of the labor is required at the finishing end of the process while most of the energy is consumed in coke-, iron-, and steelmaking. These figures have important implications for the objectives of new technologies with which one might wish to replace existing operations.

Sizing Up the Competition

The relatively old manufacturing facilities and high wage rates prevailing in the United States force our steel industry to face stiff competition from overseas. On average, during the past few years U.S. steel imports have been about 14 per cent of domestic consumption.

This competition may be classified into two categories. Steel produced in several West European countries, such as England, Italy, and France, comes from plants which are partially or fully government-owned and is often sold in the U.S. market at prices which are substantially below the costs of production. In general such competition is not based on any technological advantage enjoyed by the exporters; remedial action, if desired, would have to be effected in the political arena.

Other competition, notably that being provided by such countries as Japan and Korea, is based on superior efficiency achieved in modern facilites and on wage rates which are low compared with those prevailing in the United States.

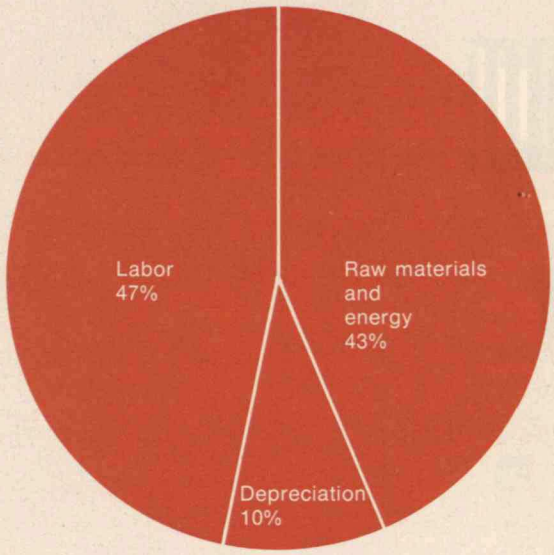
When the American steel industry is compared with that of Japan, for example, the overall conclusion is inescapable: Japanese steelmakers have facilities which are much more technologically efficient than ours — large, well-laid-out, modern plants, integrated operation, large blast furnaces, more continuous casting, more instrumentation and computer control, careful attention to operational details, and lower specific energy consumption. The energy consumed to make one ton of steel in Japan is now as much as a third lower than that in the United States, and the total production cost in Japan for finished steel is about $60 per ton less than in the United States. (This figure is given in the 1977 report of the Council on Wage and Price Stability; it will have been affected by the recent change in exchange rates.)

While Japan has built several ultramodern facilities — Oita and Ogishima are examples — during the last 20 years the United States has been able to build only one new, fully integrated steel plant, Bethlehem Steel Corp.'s mill in Burns Harbor, Ind.

Three factors are responsible for the rapid development of steelmaking in Japan since World War II:

☐ The benign and even supportive policies of the Japanese government;

☐ The ready availability of capital to finance new developments — nearly 40 per cent more than in the United States and Canada.



The steel industry is labor- and energy-intensive. Nearly half of the cost of a ton of steel is due to labor, and over 40 per cent is due to raw materials and energy. Part of the steel industry's present malaise stems from the fact that the cost of these two inputs is rising faster than other costs in the economy as a whole.

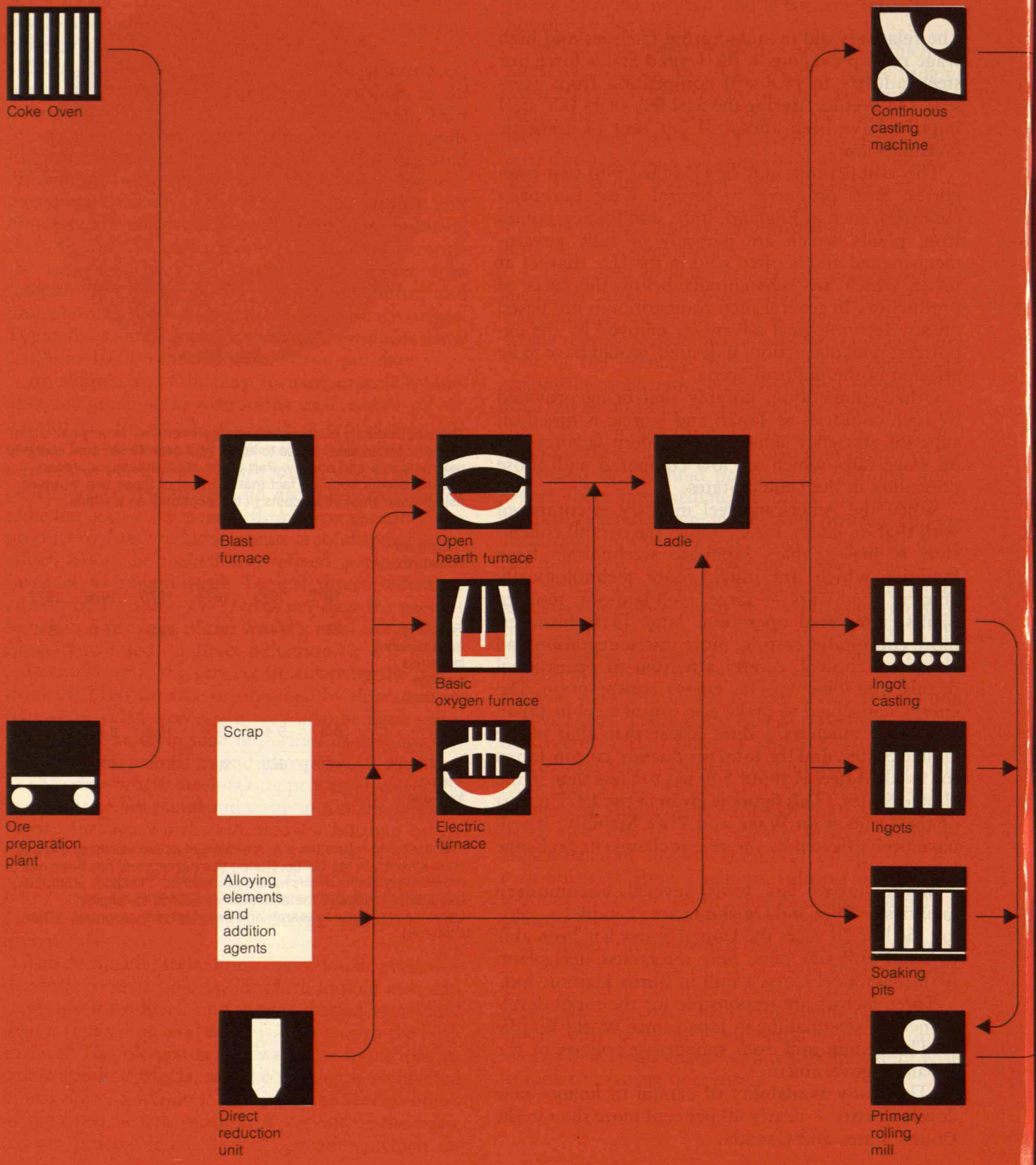
Return on net worth

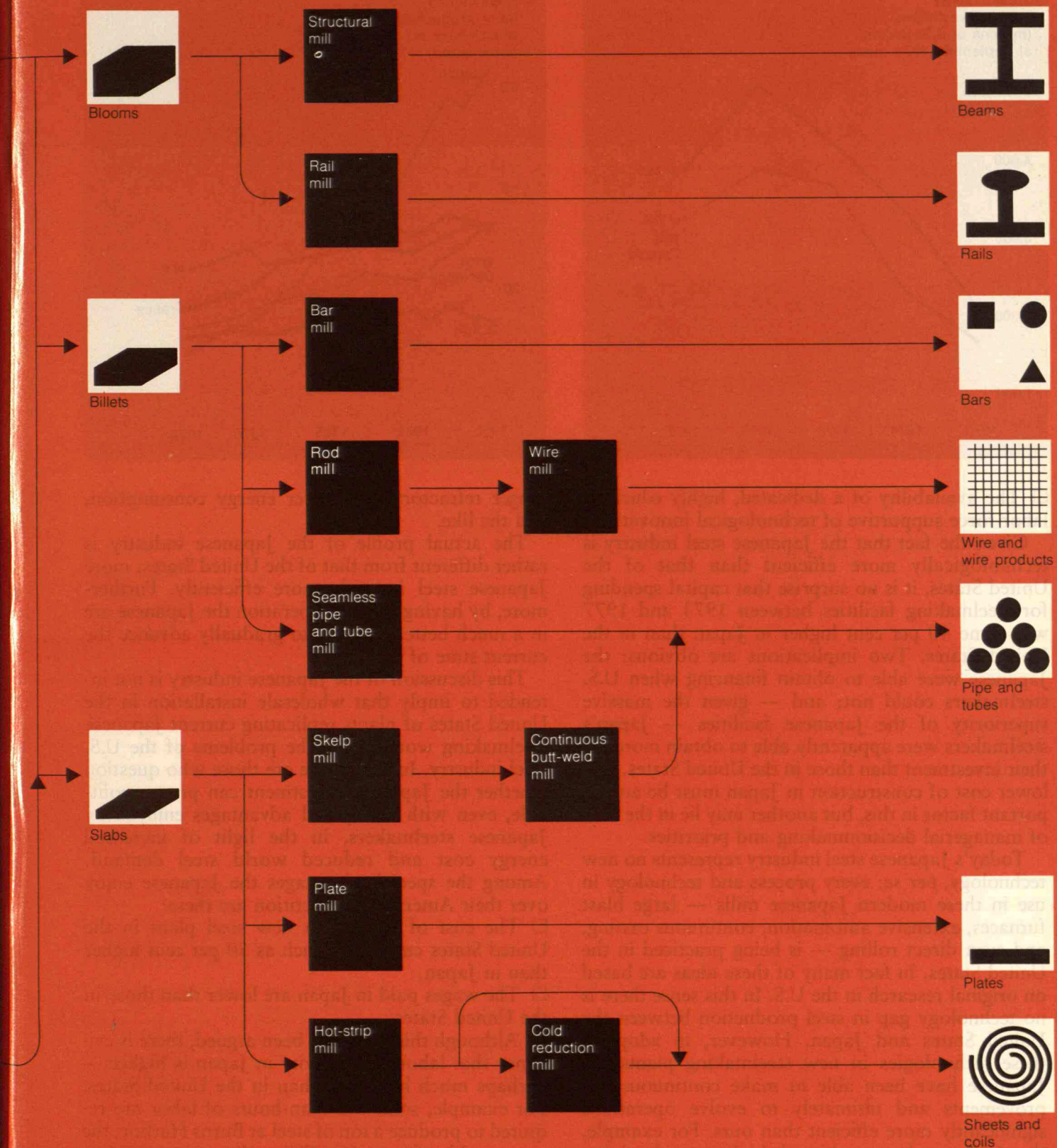
	1972	1973	1974	1975	1976	1977
Forty-one manufacturing industries average (per cent)	12.1	14.9	15.2	12.3	15.0	15.0
Steel	6.2	9.4	17.1	10.3	8.4	6.6
Steel's rank among forty-one	40th	36th	9th	27h	40th	41st

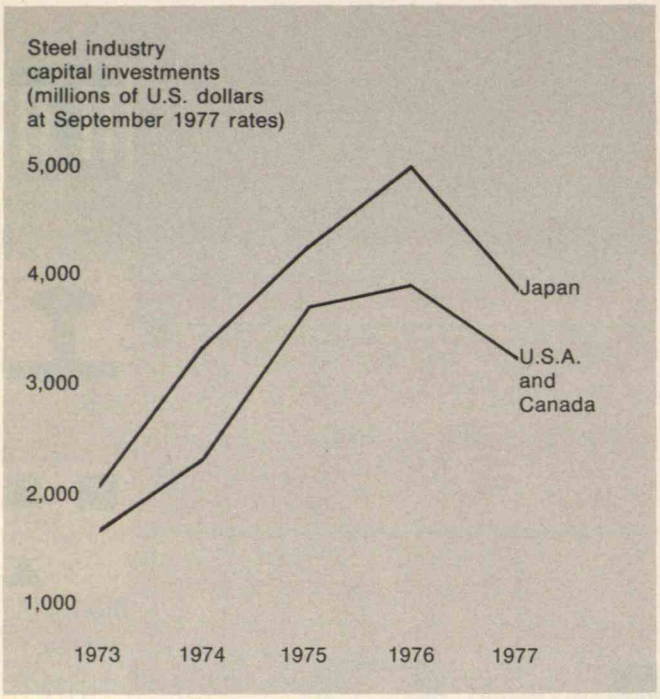
The declining return (as a percentage of its net worth) of the U.S. steel industry in the 1970s. During this period steel has been one of the least profitable of this nation's industries. This poor profitability has sharply reduced the availability of funds for capital improvements and research and development programs. (Data: Citibank)

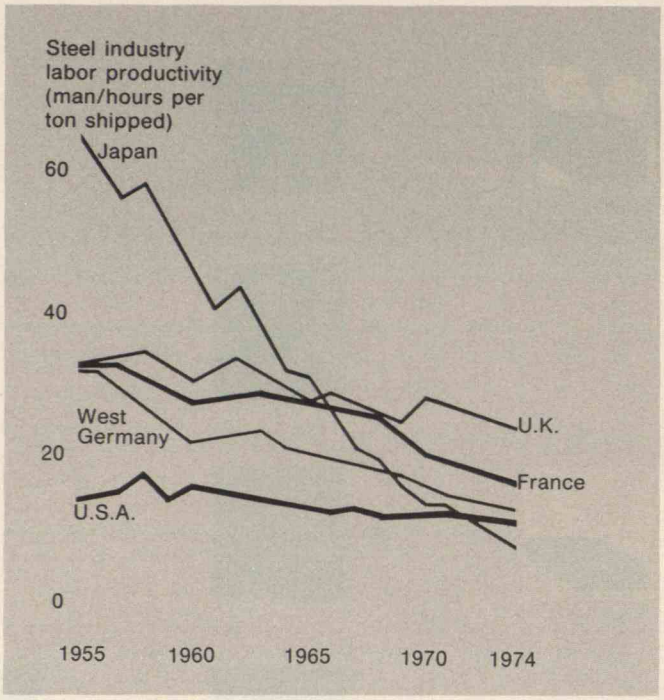
Ironmaking, steelmaking, and steel forming — current technology

The technology of conventional steelmaking. The process of raw materials (including coal) preparation, ironmaking, steelmaking, and preliminary finishing to produce forms of solid metal called "blooms," "billets," and "slabs" are all included in what is traditionally called the "primary" end of steelmaking. These intermediate products are then brought into the forms required by their users — sheet, plate, rod, and the like — in the "finishing" end of the process.




Blooms
Structural mill
Beams
Rail mill
Rails
Billets
Bar mill
Bars
Rod mill
Wire mill
Wire and wire products
Seamless pipe and tube mill
Pipe and tubes
Slabs
Skelp mill
Continuous butt-weld mill
Plate mill
Plates
Hot-strip mill
Cold reduction mill
Sheets and coils





☐ The availability of a dedicated, highly educated labor force supportive of technological innovation.

Given the fact that the Japanese steel industry is technologically more efficient than that of the United States, it is no surprise that capital spending for steelmaking facilities between 1973 and 1977 was some 40 per cent higher in Japan than in the United States. Two implications are obvious: the Japanese were able to obtain financing when U.S. steelmakers could not; and — given the massive superiority of the Japanese facilities — Japan's steelmakers were apparently able to obtain more for their investment than those in the United States. The lower cost of construction in Japan must be an important factor in this, but another may lie in the area of managerial decisionmaking and priorities.

Today's Japanese steel industry represents no new technology, *per se;* every process and technology in use in these modern Japanese mills — large blast furnaces, extensive automation, continuous casting, and even direct rolling — is being practiced in the United States. In fact many of these ideas are based on original research in the U.S. In this sense there is no technology gap in steel production between the United States and Japan. However, in adopting these technologies in new steelmaking plants the Japanese have been able to make continuous improvements and ultimately to evolve operations significantly more efficient than ours. For example, the Japanese have achieved higher productivity, longer refractory life, lower energy consumption, and the like.

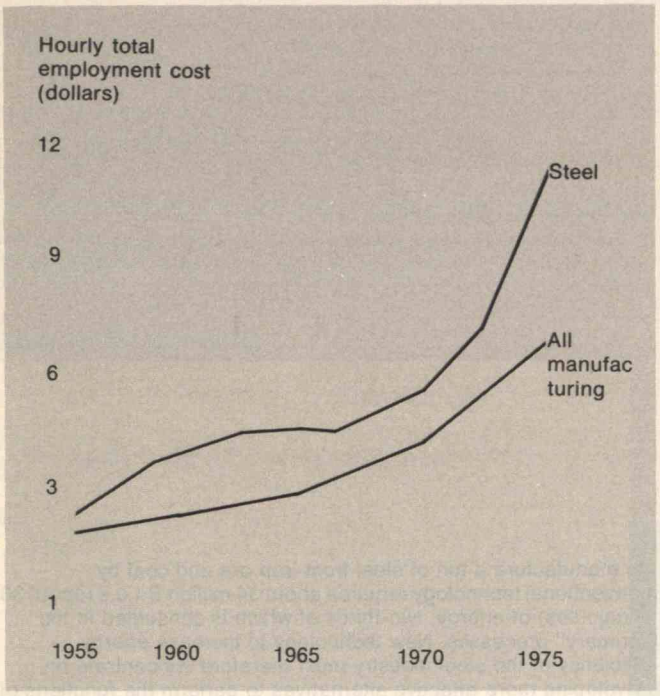
The actual profile of the Japanese industry is rather different from that of the United States: more Japanese steel is made more efficiently. Furthermore, by having modern operation the Japanese are in a much better position to gradually advance the current state of the art.

This discussion of the Japanese industry is not intended to imply that wholesale installation in the United States of plants replicating current Japanese steelmaking would solve the problems of the U.S. steel industry. Indeed, there are those who question whether the Japanese investment can prove profitable, even with the special advantages enjoyed by Japanese steelmakers, in the light of increased energy cost and reduced world steel demand. Among the special advantages the Japanese enjoy over their American competition are these:

☐ The cost of building a new steel plant in the United States can be as much as 50 per cent higher than in Japan.

☐ The wages paid in Japan are lower than those in the United States.

☐ Although this point has been argued, there is evidence that labor productivity in Japan is higher — perhaps much higher — than in the United States. For example, some 3.6 man-hours of labor are required to produce a ton of steel at Burns Harbor; the comparable figure for Oita, the most modern



Far left: Capital investment in iron- and steelmaking facilities has been greater in Japan than in North America during the past five years. But the payoff from these investments seems to have been disproportionate: the Japanese steel industry is now technologically far more efficient than ours. (Data: International Iron and Steel Institute cited by *Iron and Steel Engineer*).

Center: Steel industries' productivity as measured in man-hours of labor required per ton of steel production. Japanese investments in integrated, large-scale steel production facilities during the past two decades have spectacularly decreased the labor required for steelmaking, and now the Japanese steel industry appears to be the most efficient — by this measure — of any in the world. (Data: Bela Gold in *Iron and Steel Engineer*)

Left: Employment cost per worker in American manufacturing industries. While the productivity of U.S. steelworkers (measured by man-hours of labor required per ton of steel production) has improved modestly in the post-war years (see chart, page 27), wages have increased sharply — at a rate considerably greater than the average of workers in all U.S. manufacturing industry. (Data: Bureau of Labor Statistics and American Iron and Steel Institute from the Council on Wage and Price Stability)

Japanese plant, is 2.1 man-hours per ton of steel. (This comparison may not be entirely fair, because the labor requirements depend quite critically on the product mix; nonetheless, one would expect general agreement with the contention that the labor productivity in the *modern* Japanese plants is much higher than in the U.S.)

Since labor costs represent some 40 to 45 per cent of the total cost of steel, the combination of labor productivity and wage rates may be important in determining the competitiveness of an industry. The comparison is obvious in the case of the United States and Japan: labor productivity has been improving consistently in Japan but has remained almost unchanged in the United States for 20 years *(see chart, page opposite)*; meanwhile, the labor force in the U.S. steel industry has obtained very impressive gains in wages — far in excess of the average for the U.S. economy as a whole *(above)*.

Time to Take Action

If the trends of today, toward lower production and lower profits among U.S. steelmakers, are to be reversed and the U.S. steel industry is to be preserved as a viable entity, action is required in three time frames.

Immediate economic and political remedies such as the anti-dumping legislation, tariff barriers, and voluntary import quotas would protect the U.S. industry from further invasion of its markets. Other complementary measures could include loan guarantees and more attractive investment credit to stimulate modernization, the encouragement of capital formation, and the removal of legal barriers to cooperative research or even commercial ventures between steel corporations.

Improving Today's Technology

Over the intermediate term (say two to ten years), new investment to modernize and round out our best facilities could be attractive and profitable. Though these would improve efficiency, their beneficial effect on the cost of steel is unlikely to be overwhelming. The additional cost savings overall might reach $70 per ton, or say 20 per cent.

Improvements which conserve energy and reduce raw materials costs are more appealing than approaches which save labor, because the cost of energy is rising more rapidly than other costs; furthermore, savings in energy and raw materials are readily realized while increased labor productivity is generally accompanied by demands for wage increases.

Some possibilities for improving existing technology include:

☐ Upgrade blast furnace performance by more careful preparation of the iron ore feed and the coke and by ancillary fuel injection. This would increase

the throughput and reduce the volume of slag and hence would increase the overall thermal efficiency of the process. Further gains should be possible through the replacement of small blast furnaces with larger units.

Since ironmaking is a costly operation (it represents some 40 per cent of the total cost of steel) and is a heavy consumer of energy, the blast furnace is a prime candidate for improvement.

☐ Make technological changes in the manufacture of coke, preheating the coal prior to charging into coke ovens; the use of lower grade coal as feedstock, the use of coke oven gas as a fuel in direct reduction processes, and the use of coal directly (instead of coke) in ironmaking. The latter is especially appealing because of the increasing cost of coking coal, the high cost of complying with pollution control regulations, and the very high cost of constructing coke ovens.

☐ Combine coal gasification, coal liquefaction, and perhaps waste incineration with steel production. For example, hot gases generated by burning urban waste might be used for direct reduction; the flammable by-products of coal liquefaction might be used for blast furnace injection; blast furnaces might be operated with oxygen-enriched blasts, so that the offgas would have a higher energy value and thus find more general use; waste heat from steel plants might be used for district heating or air conditioning — a proposal particularly appropriate for plants located in urban areas; and the carbon monoxide in basic oxygen furnace offgases could be recovered and used for direct reduction or as a fuel.

☐ Use continuous casting more extensively. Continuous casting provides appreciable savings of both labor and energy, and its more widespread adoption should be attractive.

☐ Increase automation and computer control of operations. This would substantially improve product quality and consistency while decreasing costs by reducing energy consumption and labor requirements. On-line inspection of billets and slabs in the finishing sequence would be a precursor to fully continuous, direct rolling operations.

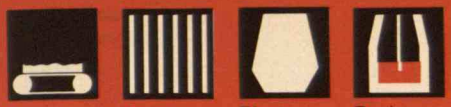
☐ Rationalize product types and production schedules. Most steel plants in the United States manufacture a wide range of products. This causes appreciable scheduling problems, both in production and shipping. The reduction of product types could afford appreciable economies.

The last two alternatives appear to be particularly attractive because they offer cost reduction without

To manufacture a ton of steel from iron ore and coal by conventional technology requires about 34 million B.t.u.s (about 36 Gigajoules) of energy, two-thirds of which is consumed in the "primary" processes. New technology to increase energy efficiency of the steel industry must therefore concentrate on developing more effective alternatives to perform the functions of the coke oven, blast furnace, and steelmaking units.

Labor cost contributes some 35 to 45 per cent of the total cost of production. Of this figure 25 per cent is used in the primary end and 75 per cent in the finishing end. New technology which decreases labor requirements is therefore of special leverage here.

The total capital cost of a modern, integrated steel plant built today in the U.S. would be about $1,200 per annual ton of production. This cost would be about equally divided between the "primary" and "finishing" stages; thus new technology which has the effect of decreasing capital requirements would be appropriate throughout the process.



Energy, labor, and capital costs in primary and finishing processes of direct steelmaking

Primary end

Consumes 65% of total energy

25% of total labor cost

50% of total capital cost

Finishing end

Consumes 35% of total energy

75% of total labor cost

50% of total capital cost

substantial capital investment. Furthermore, they rely on techniques of systems analysis, computer modeling and control which are familiar in many U.S. manufacturing operations.

Radically Innovative Technologies

No matter how essential such actions as those described are over the short term, they cannot solve the industry's long-term problems. Only radically new manufacturing technologies can assure that the U.S. steel industry can remain viable into the 21st century. Such technologies would reduce energy consumption, allow the use of cheaper raw materials, require fewer personnel in operation and maintenance, produce less environmental pollution, and meet more stringent product specifications — all at a lower capital cost. This panacea is not within easy reach, but we can propose some new technologies appropriate to these goals.

Direct Steelmaking Processes

One of these is direct steelmaking (*see diagram, page 37*), in which iron ore is transformed to steel with no intermediate stage. This is proposed to be done by feeding a mixture of coal and iron ore into a molten steel bath, accompanied by oxygen injection. The reduction of iron oxide to iron would take place in the molten state, with the heat of reaction supplied by the combustion of the carbon with oxygen. Such direct processes are attractive because coke is not required, because cheaper grades of coal may be used, and because ironmaking and steelmaking steps are combined. Furthermore, the carbon monoxide that is produced is given up in a continuous manner so that its subsequent utilization can be more straightforward.

Direct steelmaking could save energy, capital and labor costs; no coke ovens or blast furnaces would be needed.

The principal problems to be overcome include the containment of the system, the difficulties associated with the coexistence of oxidizing and reducing reactions within the same vessel, the feeding of the raw materials, and the management of start-up and shut-down. Some of these problems have resisted solution in a number of developmental tests, and it may be that ultimately no satisfactory resolution will be found; direct steelmaking is definitely not an established technology.

A possible variant of direct steelmaking is the so-called "S" process. In essence, it combines a direct reduction unit and a pellet melting operation into a single stage, using fossil fuels. The pellets are melted in a vertical-shaft furnace using a reducing flame, and the gases leaving the melting unit are used, after some treatment, to carry out the direct reduction. In principle, this process — it has been demonstrated on the scale of 1 ton per hour — could offer savings of 20 to 30 per cent in energy consumption and substantial savings in capital cost.

Plasma Arc Steelmaking

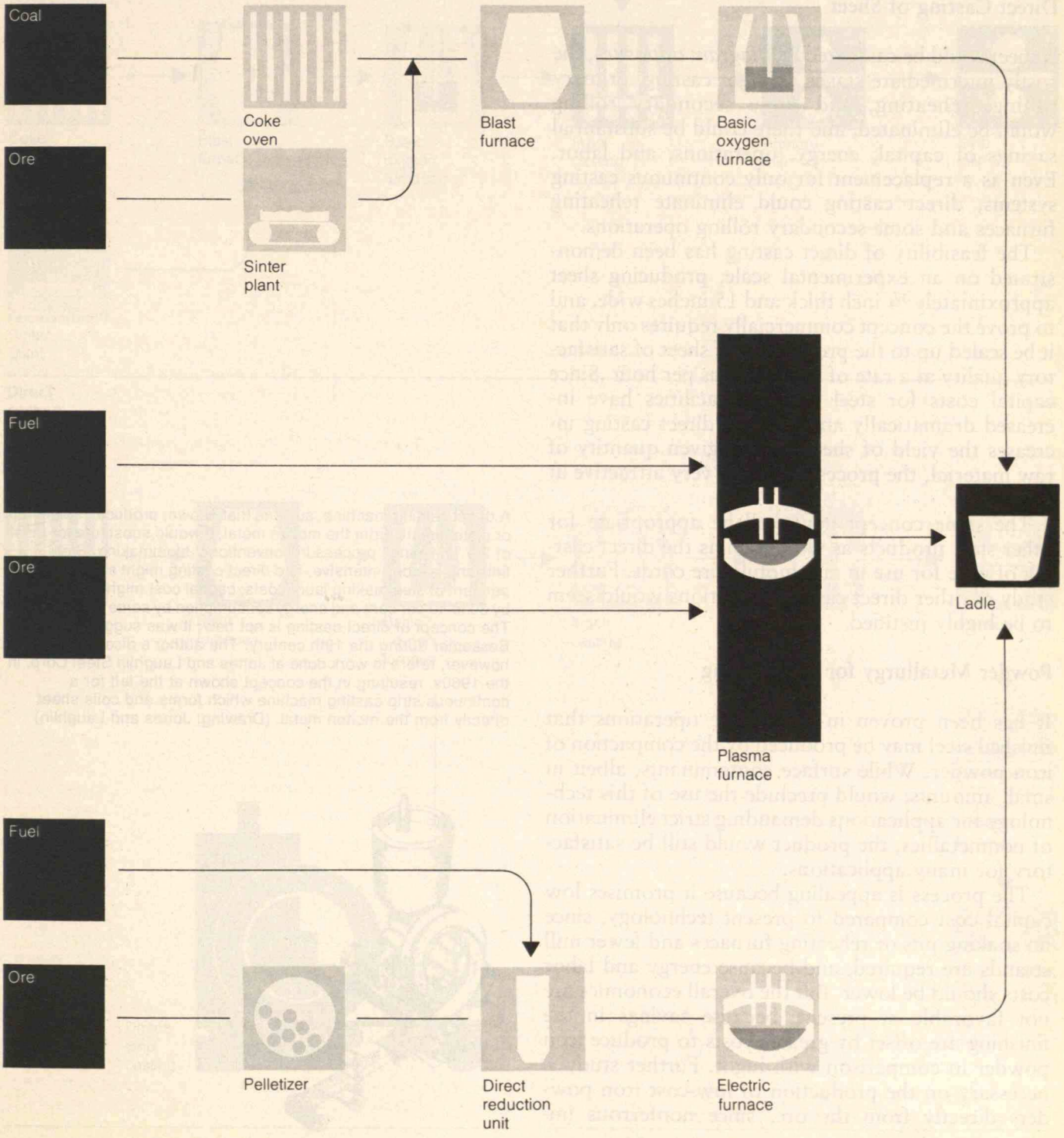
Plasma arc steelmaking (*see diagram opposite*), under investigation for a number of years, involves the creation of a stable arc of extremely high temperature between two electrodes. A mixture of ore and fuel passed through this high-temperature zone would react to produce molten iron.

This technology is appealing for several reasons. Its capital cost would be relatively low, since no coke ovens or blast furnaces would be required. Plasma arc steelmaking may make possible the manufacture of specialty steels directly without the need for additions to the molten product; for example, iron ore could be mixed with chrome and nickel ores in advance of treatment to produce a chrome-nickel steel. Economies of scale come into play at much lower tonnages with the plasma arc process. A modern blast furnace is economical only for production of a minimum of two to four million tons a year. But plasma steelmaking facilities producing 200,000 tons per year could operate efficiently, and this leads to the concept of a mini-mill, an interesting alternative to large, integrated steel plants. Quite a number of mini-mills, using electric arc furnaces, operate successfully at present in the U.S. Under certain conditions steel can be made in plasma arcs without the need for high-grade iron ores; this technology may be applicable to the recycling of in-plant wastes, such as dust from oxygen furnaces, as well; work is being done in East Germany on the use of plasma systems for melting scrap.

The main drawback of plasma arc systems is the power consumption, estimated to be in the range of 2,000 kilowatt-hours per ton which is comparable to the fossil fuel requirements of the conventional steelmaking operation. It follows that the attractiveness of plasma arc systems will depend critically on the cost of electric power compared to that of other fuels and also on the efficiency of waste gas recovery.

Plasma steelmaking

Plasma arc steelmaking would substitute a single electrically powered furnace for the "primary" stages in the conventional steelmaking process. Energy savings are problematical, but the process is suited to smaller-scale steelmaking plants, where capital costs could be 10 to 20 per cent less than conventional systems and labor requirements 10 to 15 per cent lower.



While the operation of plasma arc systems has been demonstrated in the laboratory, the hundredfold scale-up to the projected commercial size of 50 to 100 megawatts may pose problems, including those of containment and electrode wear.

Direct Casting of Sheet

If sheet could be cast directly (*diagram opposite*), the costly intermediate stages of ingot casting, primary rolling, reheating, and some secondary rolling would be eliminated, and there could be substantial savings of capital, energy, operations, and labor. Even as a replacement for only continuous casting systems, direct casting could eliminate reheating furnaces and some secondary rolling operations.

The feasibility of direct casting has been demonstrated on an experimental scale, producing sheet approximately ¼ inch thick and 15 inches wide, and to prove the concept commercially requires only that it be scaled up to the production of sheet of satisfactory quality at a rate of say 100 tons per hour. Since capital costs for steel finishing facilities have increased dramatically and because direct casting increases the yield of sheet from a given quantity of raw material, the process could be very attractive at present.

The same concept may well be appropriate for other steel products as well, such as the direct casting of wire for use in automobile tire cords. Further study of other direct casting operations would seem to be highly justified.

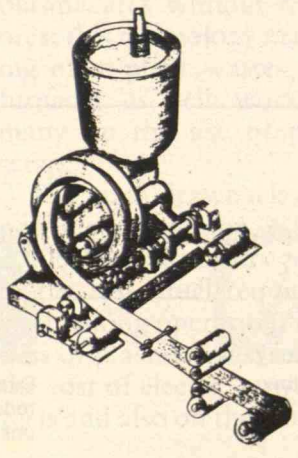
Powder Metallurgy for Steelmaking

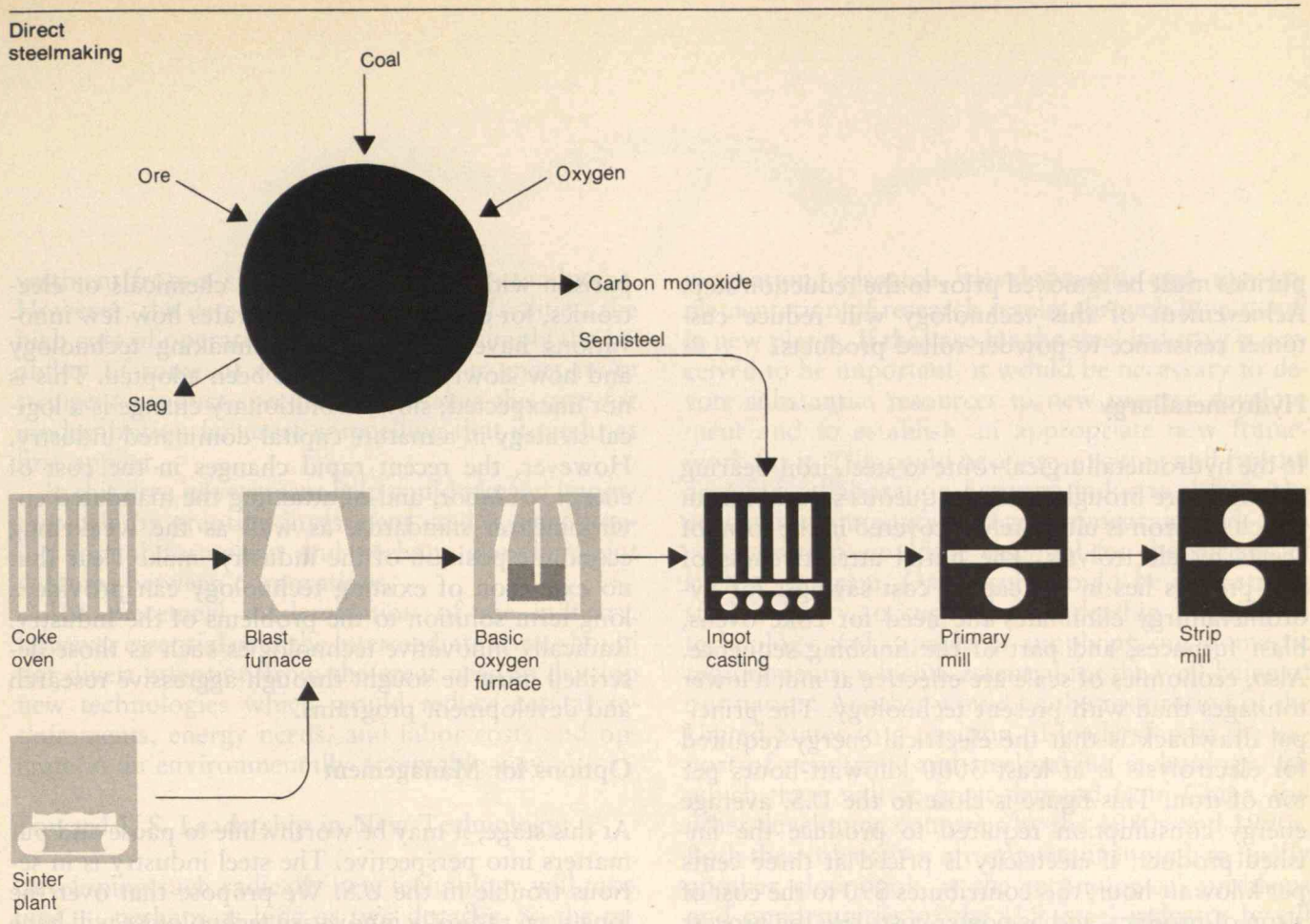
It has been proven in small-scale operations that finished steel may be produced by the compaction of iron powder. While surface contaminants, albeit in small amounts, would preclude the use of this technology for applications demanding strict elimination of nonmetallics, the product would still be satisfactory for many applications.

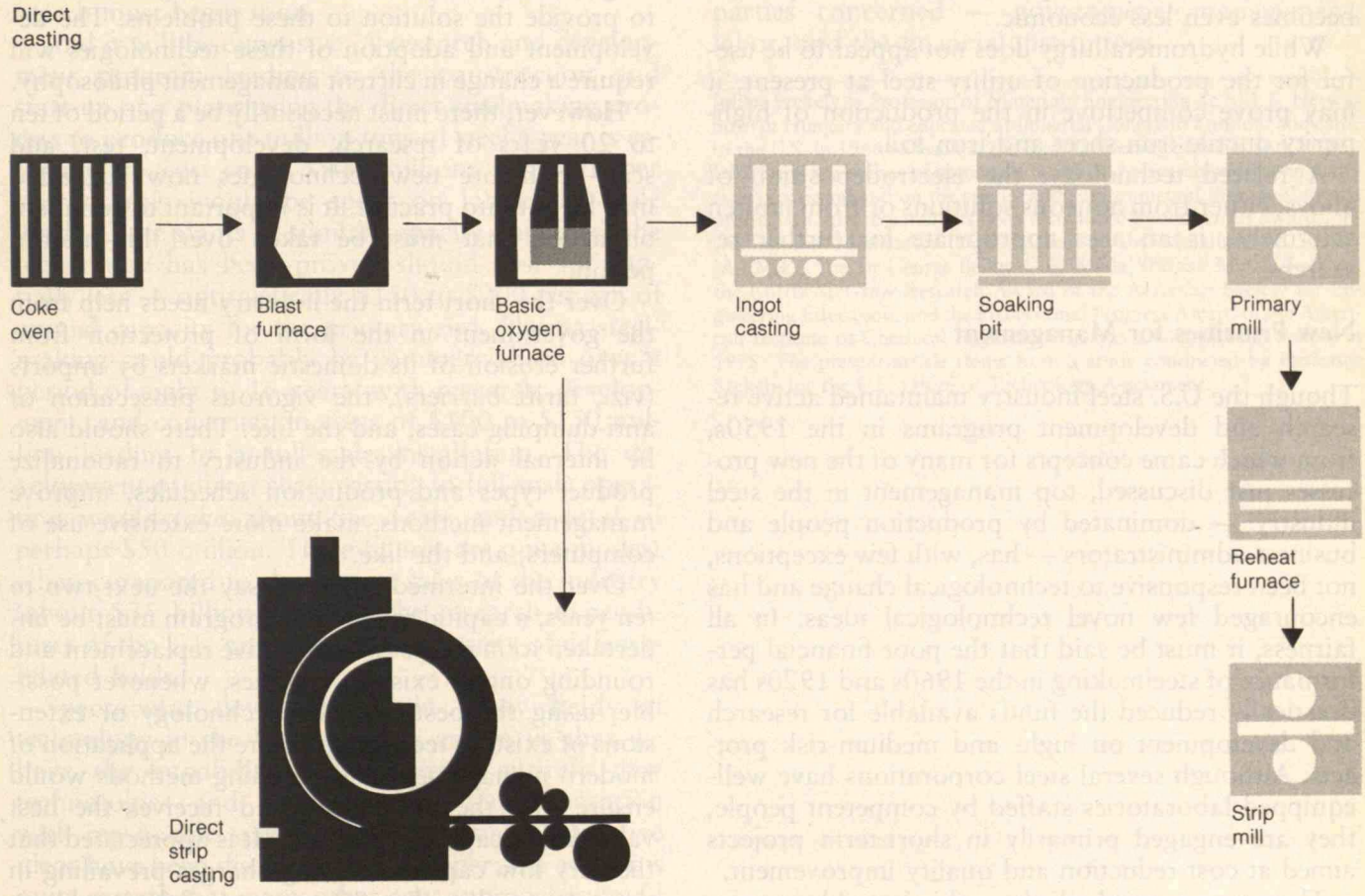
The process is appealing because it promises low capital cost compared to present technology, since no soaking pits or reheating furnaces and fewer mill strands are required, and because energy and labor costs should be lower. But the overall economics are not favorable at present, because savings in the finishing are offset by greater costs to produce iron powder in comparison with ingot. Further study is necessary on the production of low-cost iron powders directly from the ore, since nonferrous im-

Direct steelmaking would replace by a single process the coke oven, sinter plant, blast furnace, and the oxygen (steelmaking) furnace in the conventional "primary" steelmaking process. It could reduce labor cost by 10 to 15 per cent and energy consumption by 20 to 25 per cent; the capital cost of new direct steelmaking facilities is estimated at about 20 per cent less than for conventional coking, ironmaking, and steelmaking equipment.

A direct casting machine, such as that shown, produces steel strip or plate directly from the molten metal; it would substitute for most of the "finishing" process in conventional steelmaking. Steel finishing is labor-intensive, and direct casting might save 40 to 50 per cent of steelmaking labor costs; capital cost might be reduced by 30 to 40 per cent and energy consumption by some 15 per cent. The concept of direct casting is not new; it was suggested by Bessemer during the 19th century. The author's discussion however, refers to work done at Jones and Laughlin Steel Corp. in the 1960s, resulting in the concept shown at the left for a continuous strip casting machine which forms and coils sheet directly from the molten metal. (Drawing: Jones and Laughlin)




Direct steelmaking
Coal
Ore
Oxygen
Carbon monoxide
Semisteel
Slag
Coke oven
Blast furnace
Basic oxygen furnace
Ingot casting
Primary mill
Strip mill
Sinter plant


Direct casting
Coke oven
Blast furnace
Basic oxygen furnace
Ingot casting
Soaking pit
Primary mill
Reheat furnace
Strip mill
Direct strip casting

purities must be removed prior to the reduction step. Achievement of this technology will reduce customer resistance to powder-rolled products.

Hydrometallurgy

In the hydrometallurgical route to steel, iron-bearing materials are brought into an aqueous solution from which the iron is ultimately recovered in the form of sheets by electrolysis. The initial attractiveness of this process lies in the capital cost savings, for hydrometallurgy eliminates the need for coke ovens, blast furnaces, and part of the finishing sequence. Also, economies of scale are effective at much lower tonnages than with present technology. The principal drawback is that the electrical energy required for electrolysis is at least 3000 kilowatt-hours per ton of iron. This figure is close to the U.S. average energy consumption required to produce the finished product. If electricity is priced at three cents per kilowatt hour, this contributes $90 to the cost of a ton of product, and as power costs rise the process becomes even less economic.

While hydrometallurgy does not appear to be useful for the production of utility steel at present, it may prove competitive in the production of high-purity ductile iron sheet and iron foil.

A related technology, the electrodeposition of alloys, either from aqueous solutions or from molten salt melts, is an area appropriate for further research.

New Priorities for Management

Though the U.S. steel industry maintained active research and development programs in the 1950s, from which came concepts for many of the new processes just discussed, top management in the steel industry — dominated by production people and business administrators — has, with few exceptions, not been responsive to technological change and has encouraged few novel technological ideas. In all fairness, it must be said that the poor financial performance of steelmaking in the 1960s and 1970s has drastically reduced the funds available for research and development on high- and medium-risk projects. Although several steel corporations have well-equipped laboratories staffed by competent people, they are engaged primarily in short-term projects aimed at cost reduction and quality improvement.

There appears to be little sophisticated long-term planning going on in the steel industry; any comparison with other industries — chemicals or electronics, for example — demonstrates how few innovations have occurred in steelmaking technology and how slowly changes have been adopted. This is not unexpected; slow, evolutionary change is a logical strategy in a mature capital-dominated industry. However, the recent rapid changes in the cost of energy, of labor, and of attaining the mandated environmental standards, as well as the weakening economic position of the industry, make clear that no extension of existing technology can provide a long-term solution to the problems of the industry. Radically innovative technologies such as those described must be sought through aggressive research and development programs.

Options for Management

At this stage, it may be worthwhile to pause and put matters into perspective. The steel industry is in serious trouble in the U.S. We propose that over the long term radically innovative technologies will have to provide the solution to these problems. The development and adoption of these technologies will require a change in current management philosophy.

However, there must necessarily be a period of ten to 20 years of research, development, test, and scale-up before new technologies now suggested may be put into practice. It is important to comment on action that must be taken over this interim period.

Over the short term the industry needs help from the government in the form of protection from further erosion of its domestic markets by imports (viz., tariff barriers), the vigorous prosecution of anti-dumping cases, and the like. There should also be internal action by the industry to rationalize product types and production schedules, improve management methods, make more extensive use of computers, and the like.

Over the intermediate term, say the next two to ten years, a capital investment program must be undertaken to make possible selective replacement and rounding out of existing facilities, whenever possible, using the best available technology or extensions of existing technology. Here the application of modern management and planning methods would ensure that the industry indeed receives the best value for its capital investment. It is appreciated that the very low capital servicing charges prevailing in the industry (less than 10 per cent of the total production costs) might mitigate against new capital in-

vestment from a short-term accounting standpoint. However, the deterioration of existing facilities, the high cost of operating old plants, and simply the inability of some of the old facilities to meet more stringent product specifications makes the case for modernization far more compelling that it might at first appear.

In this area government help could play an important role by granting investment credits, encouraging capital formation and perhaps allowing joint ventures between corporations.

The piecemeal modernization of the industry, however essential over the intermediate term, should not divert attention from the great need to develop new technologies which would reduce capital requirements, energy needs, and labor costs and operate in an environmentally acceptable way.

Toward U.S. Leadership in New Technology

Developing such radically new technology will take time — perhaps as long as two decades. So the research must begin soon.

And it will be expensive. A research and development program leading to the construction and start-up of a plant using the direct steelmaking process to produce one million tons of steel a year is estimated to cost some $500 million; about 10 per cent of this would be spent on laboratory-scale work. Later plants of similar capacity built after the technology has been proven should cost substantially less — optimistically $150 to $200 per ton of annual capacity for the primary end. Plasma steelmaking could probably be commercialized over a period of eight to 16 years, with research, development, and construction costs of $100 to $150 million leading to a full-scale installation. The development of direct sheet casting to full-scale operation would take about five years and a total of perhaps $50 million. These figures are quite modest when compared to the annual sales of the industry (about $35 billion) or with the research expenditures of the U.S. government in a variety of defense-related fields.

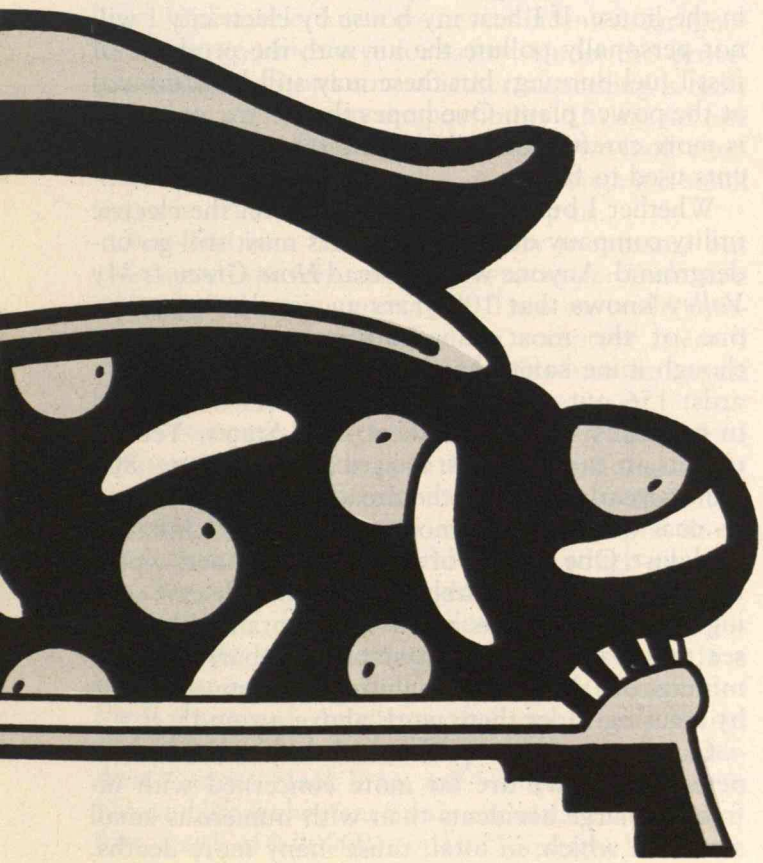
Spectacular developments in many fields of technology in the United States assure us that we have the capability of pioneering entirely new technologies and effecting their implementation with reasonable speed. Some potentially attractive ideas have been discussed in this paper; the author is quite certain that many other new approaches could be developed, provided a better climate is created for innovation, research, development, and the implementation of research results through investment in new plants. If the case for the steel industry is perceived to be important, it would be necessary to devote substantial resources to new process development and to establish an appropriate new framework for it. This could be a very exciting and fruitful area for collaboration between industry, labor, the academic community, and government; indeed, such collaboration would be essential for the success of such a program. One result would be that strong steel industry, occupying a leadership position in technology and capable of supplying our domestic requirements, which is essential for the well-being of our nation. Another would be the restoration of the United States to a position of leadership in the export of new iron- and steelmaking technology, for which there will be great demand from China and other developing countries by the 1980s and 1990s. Both these objectives are important enough to justify another close look at the technological problems and opportunities of the U.S. steel industry by all parties concerned — government, management, labor, and the financial institutions.

Julian Szekely is Professor of Materials Engineering at M.I.T. He was born in Hungary and educated at Imperial College in London, and came to the U.S. in 1966 to teach at the State University of New York at Buffalo. He is the author of numerous books and research articles on materials processing and on the energy and environmental aspects of metals production. His research has been recognized by numerous awards, including the Mathewson Gold Medal of the Metallurgical Society (A.I.M.E.), the Sir George Beilby Gold Medal (British Metals Society), the Curtis McGraw Research Award of the American Society for Engineering Education, and the Professional Progress Award of the American Institute of Chemical Engineers. He was a Guggenheim Fellow in 1975. The present article stems from a study conducted by Professor Szekely for the U.S. Office of Technology Assessment.

Analyzing the Daily Risks of Life

by Richard Wilson

In our most trivial activities we incur risks. These hazards can be quantified and compared, but can they be eliminated from our lives?



Anthony Schultz

The world seems a very hazardous place. Every day the newspapers announce that some chemical has been found to be carcinogenic, or some catastrophic accident has occurred in some far-off place. This leads some of us to hanker after a simpler world where there are fewer risks to life. But does such a world really exist?

If we look back at the world of a century ago, we find that expectation of life was 50 years; now it is 70 years. Therefore the sum of all the risks to which we are now exposed must be less than it was. We find that many of the large risks of the last century have been eliminated, leaving us conscious of a myriad of small risks, most of which have always existed.

The moment I climb out of bed I start taking risks. As I drowsily turn on the light I feel a slight tingle; my house is old with old wiring and there is a small risk of electrocution. Every year 500 people are electrocuted in the United States. I take a shower, and as I reach for the soap, I wonder about the many chemicals it contains. Are they all good for the skin, as the advertisements claim? My clothes have been cleaned with the best bleaching detergent. Most bleaching agents contain a chemical that fluoresces slightly in the sunlight to enhance the whiteness. Does this make bleaches carcinogenic?

I ponder this risk as I walk down to breakfast, taking care not to fall upon the stairs. Falls kill 16,000 people per year — mostly in domestic accidents. Shall I drink coffee or tea with my breakfast? Both contain caffeine, a well-known stimulant which may be carcinogenic. I have a sweet tooth; do I use sugar which makes me fat and gives me heart disease, or saccharin which we now know causes cancer? It is better to abstain.

After breakfast I make a sandwich for lunch. My son likes peanut butter. But improperly stored peanuts can develop a mold which produces a potent carcinogen — aflatoxin. In Africa and Southeast Asia, where aflatoxin appears more frequently, it has been blamed for numerous cases of liver cancer. In our (less natural) society storage facilities are better, so the risk is less — but it is not zero.

I prefer meat. But Americans, like other prosperous people, eat too much meat. It is not certain, but a meat-heavy diet probably contributes to cancer of the colon.

I live seven miles from work and can commute by car, by bicycle, or by bus. Which has the lowest risk? To travel by bicycle would keep my weight down, and bicycle riding does not cause pollution — but

statistics show that it is more likely to involve me in an accident. And since a bicyclist is unprotected, fatal accidents are also frequent on a bicycle. A car would be safer, but a bus is safest. I am happy that I no longer have to choose between a horse and a canoe; both are more dangerous (per mile) than a bicycle.

As I approach Boston, I see the urban haze caused by air pollution. There are toxic parts of air pollution which are not visible, as well. The risk to life caused by air pollution is high. Asthma victims have known this for a long time and fled the industrialized eastern United States for the purer air of the West. A press release from a government laboratory states that air pollution kills 20,000 people a year in the eastern United States. Air pollution, though still bad, has been reduced in most cities.

I remember the pea-soup London fogs of my youth caused by burning soft coal, where I could not see ahead ten feet; and the infamous week in December of 1952 where 3,000 people died from air pollution in four days.

I go to a committee meeting in a small, unventilated room. Although I don't smoke tobacco, half of the committee does, and I am exposed to the poison which causes 40 per cent of all cancers and kills 15 per cent of all Americans. Even though I breathe less tobacco smoke than my smoking colleagues, I often get a headache. One of my friends, who is more allergic than I, wears goggles at work.

At mid-morning I take a drink of water. The water tastes of chlorine, showing that the city's sanitation engineers use chlorine to kill microbes in the water. By such methods the country has nearly wiped out cholera and typhus. But the chlorine reacts with organic matter in the water to produce many known carcinogens. One of them, chloroform, is produced in a concentration of 100 parts per billion; enough to present a health hazard.

My office walls are brick and cinder block. Both contain radioactive materials, and radiation can increase my risk of cancer. One of these radioactive materials, radon, is a gas which is not chemically active. It is released by the brick and I can breathe it, which accentuates the hazard. I could prevent the release of this radioactive gas by painting the walls with thick epoxy paint to seal them, but that would introduce another risk. As the epoxy paint cures, it emits gaseous chemicals which are themslves carcinogenic. Which is worse?

Radiation enters all of my life. State law requires that I have a regular chest x-ray to see whether I have tuberculosis and may convey that dread disease to my students. But this adds to my risk of cancer from radiation. Is it correct for society to demand that I accept this risk, even to protect the rest of society from a greater one?

I frequently travel to meetings. Should I go by car, bus, train, or airplane? Thirty years ago the statistics were clear; the airplane was far more dangerous than all the others, since many airplanes crashed. Now, for journeys of 1,000 miles or more, air travel is the safest. But airplane travel causes an often-ignored radiation hazard, exposure to cosmic radiation from outer space. Airplanes fly at 30,000 feet, and at that altitude cosmic radiation exposure is 40 times what it is at sea level. Even a vacation trip to the high altitudes of Colorado and Wyoming can increase cosmic ray exposure. Sunlight at these altitudes, and excessive exposure even at sea level, showers us with ultraviolet light, which causes skin cancer.

These are personal concerns, and it might be argued that they are of no concern to anyone else, since I can avoid some of them. But in doing so I may well cause problems for others in society.

In the bad old days of my childhood we burnt coal in the house. If I heat my house by electricity I will not personally pollute the air with the products of fossil fuel burning; but these may still be produced at the power plant. One hopes the electric company is more careful about these pollutants than my parents used to be.

Whether I burn the coal myself or let the electric utility company do so, coal miners must still go underground. Anyone who has read *How Green Is My Valley* knows that 100 years ago coal mining was one of the most dangerous occupations. Even though mine safety has improved, it still has hazards: 156 out of every 100,000 miners were killed in accidents in 1972 in the United States. Yet accidents are not the worst hazard of coal mining: 800 miners yearly contract the dread black lung disease — coal workers' pneumoconiosis — from inhaling coal dust. One quarter of all American miners working in 1977 will probably contract this disease during their lifetimes. As an environmentalist I hate to see the beautiful western states laid bare by strip mining; but do I have a right to allow miners to die by refusing to let them work above ground?

Our society has a quirk which is fostered by our news media. We are far more concerned with infrequent large accidents than with numerous small accidents which, in total, cause many more deaths.

Congress was prompted into insisting on better mine ventilation to prevent black lung disease only after a much smaller number were killed in a single accident. A single accident of a school bus receives more newspaper coverage than the thousands of children killed yearly in automobile accidents.

This obsession with large accidents is getting worse. We are apprehensive at the *thought* of a large accident in a nuclear power plant, although none has happened so far, and experts are optimistic that none will ever happen. Nor is the fear unique to nuclear power. We bring to the United States considerable quantities of liquefied natural gas (LNG) and worry about the possibility of the ship leaking and blowing up. LNG *has* caused problems in the past; 30 years ago, an LNG tank, one-tenth the size of modern ones, collapsed and killed 133 people. We now know why this tank collapsed, and new tanks will not collapse in the same way since the metal from which the tanks are made has been changed.

Comparing the Risks We Face

There are those who would try to eliminate all known risks and would try to force this by law. This sounds plausible, but it creates an incentive for ignorance, not an incentive for safety. Under this procedure if we do not know whether something is risky and close our eyes to the possibility of risk, no one will bother us. On the other hand, if we look carefully and find there is a risk — even though it is small — some regulatory agency may stop us.

It would be a better policy to try to measure our risks quantitatively, and to give an *upper limit* on a risk when there is uncertainty. Then we could compare risks and decide which to accept or reject. I suspect most of us would decide to reduce the largest risks first.

To compare risks we must calculate them. As I prepared the table on page 45, I realized that an increased risk of death of one in a million is often seen as acceptable, but people instinctively think about large risks. I list here several actions which increase the chance of death in any year by one in a million.

Of course, if the risk of death in one year is increased, the risk of dying from another cause in a later year is decreased. The average expectation of life is shortened. Accidents often occur early in life, and life may be shortened 30 years by a typical accident. Cancer, black lung, and bronchitis kill later in life, and life is shortened only about 15 years. Therefore, a risk of 0.000001 (or 10^{-6}) shortens life on the

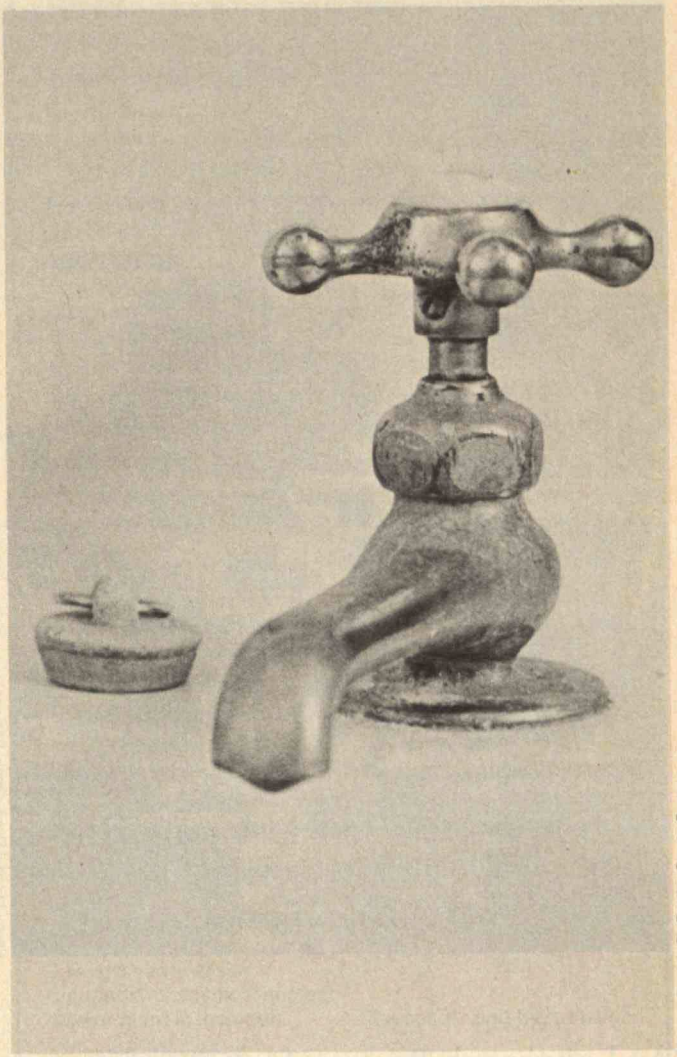


Photo: Fredrik D. Bodin, Stock, Boston

"The moment I climb out of bed I start taking risks . . . I take a drink of water . . . the chlorine reacts with organic matter to produce many known carcinogens."

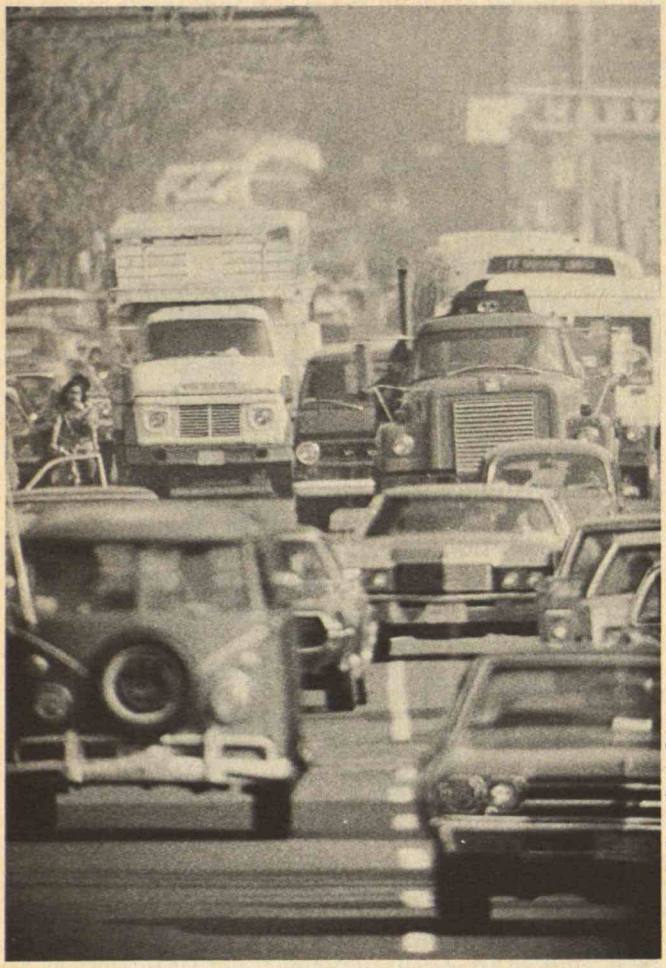


Photo: Michael Dobo, Stock, Boston

"As I approach Boston, I see the urban haze . . . Air pollution kills 20,000 people a year in the eastern U.S."

average by 30×10^{-6} years, or 15 minutes if it is an accident risk, 8 minutes if it is a risk of fatal illness.

I illustrate what this table means by calculating examples. In the United States 627 billion cigarettes were made in 1975. This is enough for 3,000 per person (including children), or a little less than half a pack a day. It is estimated that 15 per cent of all Americans (30 per cent of all smokers) die from lung or other cancers or heart disease due to smoking. We describe this as an average lifetime risk of 0.15. Dividing by the 70-year lifetime gives a yearly risk of 0.002 or 2×10^{-3}; dividing again by 3,000 gives a risk per cigarette of 0.7×10^{-6}. It is amusing to note that smoking a cigarette takes ten minutes and reduces the expectation of life by five minutes.

Human affairs are much more random than we like to think. One boy playing on a street can be killed by a passing car while his playmates are unharmed. All were equally at risk before the accident, but only one died. Similarly, one out of three lifetime smokers dies of cancer or heart disease because of the habit; the rest are unaffected and die of other causes. Moreover, those that die of cancer and heart disease do so at different ages. We have no way of telling which particular smokers will die of cancer, so we say that all are equally at risk.

It has been shown that those who smoke 40 cigarettes a day are ten times more likely to develop cancer as those who smoke four cigarettes a day. Perhaps there is a level of consumption where the risk becomes zero, but we cannot measure that low. It is easier to assume that every cigarette contributes the same amount to the total risk.

Brookhaven National Laboratory recently estimated that 20,000 Americans die every year from air pollution east of the Mississippi. This is partly due to sulphur emitted from burning coal and oil, and measurements suggest that the sulphate particulates spread themselves roughly uniformly over town and country. About 100 million Americans are exposed to this dirty air, so the average risk is 20,000/100,000,000 every year or 2×10^{-4} or 0.0002. Two days in New York City give a risk smaller by 2/365 or about 10^{-6} (one in a million).

Recent aircraft accident statistics tell us that aircraft in the United States carry passengers 100 billion passenger-miles every year and only about 100 people a year are killed in airplane crashes. This gives a risk of one in a million for one thousand miles of flight.

Professor Norman G. Rasmussen of M.I.T. made a study of nuclear reactor accident probabilities for

the Nuclear Regulatory Commission. He concluded that a reactor accident involving loss of life is very unlikely. The chance of an accident with more than 1,000 deaths is less than one in a 100 million per year of operation for each reactor. Most of these would be among the 20,000 or so people living within five miles of the reactor. So the probability of an individual living near a reactor being killed in a large accident is 1/2000 million. But those close by might also suffer in smaller accidents which, even though still unlikely, are more probable, leading to a risk of 1/50 million for persons living close to reactors.

Other more dangerous radiation hazards, such as natural radioactivity in brick, cosmic radiation, and diagnostic x-rays, are calculated by measuring the radiation dose and dividing it by the measured effect of large doses. The risks of these commonly accepted radiation hazards are far greater than those estimated for nuclear power.

I find these comparisons help me evaluate risks, and I imagine that they may help others do so, as well. But the most important use of these comparisons must be to help the decisions we make, as a nation, to improve our health and reduce our accident rate.

Taxing a Risk

Economists are fond of using taxation to control human affairs. Indeed, the invention of money by Croesus made a great simplification in the relationships in society. One suggestion, then, is to tax anyone who introduces a risk into society. This tax could pay for medical care, for compensating society for the loss of services, etc. The question arises: How much should the tax be? I suggest, as a basis for discussion, that this tax be at the rate of $1 million for every life that is lost by this extra risk, or one dollar for a risk of one in a million. Conversely, anyone that can save a life by an expenditure of $1 million must be encouraged to do so.

For example, the manufacturer who panders to the bad habit of cigarette smoking would pay an increased tax of 70 cents *per cigarette*. This is more than enough to pay the societal cost of cigarette smoking (hospital costs, fire hazards, reduced working time), which is variously estimated at from $1 to $2 per pack. Other taxes — five cents per diet soda — are less dramatic and might have to be accompanied by a tax of five cents on other sodas as well to prevent a switch to sugar.

Risks which increase chance of death by 0.000001*

Smoking 1.4 cigarettes	Cancer, heart disease
Drinking 1/2 liter of wine	Cirrhosis of the liver
Spending 1 hour in a coal mine	Black lung disease
Spending 3 hours in a coal mine	Accident
Living 2 days in New York or Boston	Air pollution
Travelling 6 minutes by canoe	Accident
Travelling 10 miles by bicycle	Accident
Travelling 300 miles by car	Accident
Flying 1000 miles by jet	Accident
Flying 6000 miles by jet	Cancer caused by cosmic radiation
Living 2 months in Denver on vacation from N.Y.	Cancer caused by cosmic radiation
Living 2 months in average stone or brick building	Cancer caused by natural radioactivity
One chest x-ray taken in a good hospital	Cancer caused by radiation
Living 2 months with a cigarette smoker	Cancer, heart disease
Eating 40 tablespoons of peanut butter	Liver cancer caused by aflatoxin B
Drinking Miami drinking water for 1 year	Cancer caused by chloroform
Drinking 30 12 oz. cans of diet soda	Cancer caused by saccharin
Living 5 years at site boundary of a typical nuclear power plant in the open	Cancer caused by radiation
Drinking 1000 24 oz. soft drinks from recently banned plastic bottles	Cancer from acrylonitrile monomer
Living 20 years near PVC plant	Cancer caused by vinyl chloride (1976 standard)
Living 150 years within 20 miles of a nuclear power plant	Cancer caused by radiation
Eating 100 charcoal broiled steaks	Cancer from benzopyrene
Risk of accident by living within 5 miles of a nuclear reactor for 50 years	Cancer caused by radiation

*(1 part in 1 million)

Photo: Peter Menzel, Stock, Boston

"I go to a committee meeting in a small, unventilated room. Although I don't smoke tobacco . . . I am exposed to the poison which causes 40 per cent of all cancers and kills 15 per cent of all Americans."

These taxes might be earmarked to pay for risk reductions such as converting an existing sanitation system to using ozone instead of chlorine for sanitation, to avoid the production of chloroform.

Whether we quantify these risks or not, we must and do constantly make decisions about them. We do this as individuals, and our politicians make these decisions for us on a larger scale. What we are not doing, and need to do, is comparing the risks of various activities and then reducing the largest risks — which may not be the obvious ones.

After calculating these risks all day, I go home. I am still faced with decisions about risks. If I cook a meal in the microwave oven and the door doesn't fit tightly, I will be exposed to microwaves. It has recently been claimed that microwaves, even at low concentrations, give people nervous problems. Or I can use the gas stove, but the burning gas can fill my kitchen with both noxious carbon monoxide and nitrogen oxides.

Just as I go to bed I take a glass of beer. Alcohol causes cirrhosis of the liver and has been associated with oral and other cancers. However, the relaxing effect of the beer will reduce my stresses and permit a good night's sleep. This will prolong my life and is worth the risk.

The beer is in a green glass bottle which contains chromium, a small amount of which enters the beer. Chromium is a known carcinogen when ingested in moderate quantities, but it must not be avoided altogether because it is essential to life in small concentrations. How much chromium should I take to minimize the risk? Is the amount in the beer too much? Should I drink the beer from a plastic bottle? A plastic bottle suitable for beer has just been banned because a trace of the chemical from which the plastic was made could dissolve in the contents, and there is a suspicion that the chemical is carcinogenic.

I ponder this decision as I put on my pajamas. Are the pajamas inflammable? There is always a small risk of a fire starting while I am in bed. Is the risk of being burnt in a fire greater or smaller than the risk of cancer caused by a flame retardant such as TRIS?

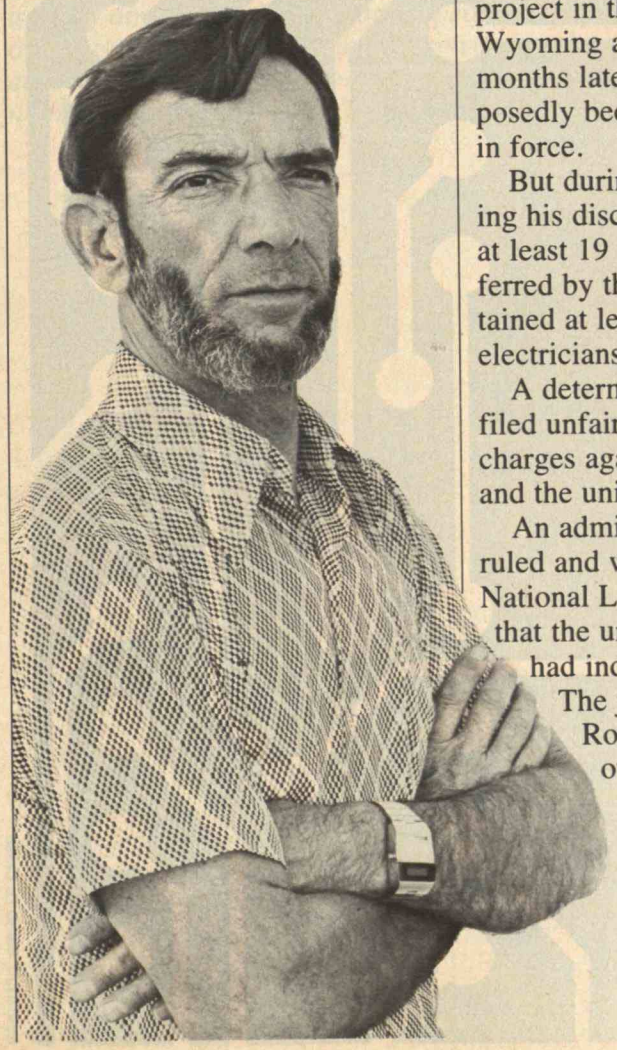
I remember the truism "more people die in bed than anywhere else," so at least I'm in the right place.

Richard Wilson is professor of physics at Harvard University. Educated at Christ Church, Oxford, he received his Ph.D. in 1950. For many years he has been concerned with energy and the environment. He served on the National Science Foundation Physics Advisory Panel, as a consultant on nuclear power to the Attorney General's Office of the state of Maine, and as a consultant to the Nuclear Regulatory Commission. He is Assistant Editor of *Annals of Physics*.

Job Discrimination... It Still Exists.

Paul Robertson is not a member of a persecuted minority. But he has experienced blatant discrimination all the same because he has chosen not to join a union.

Paul Robertson is a working man, a skilled licensed electrician with more than 20 years experience. He found out the hard way how a big company and a big union can discriminate on the job.



Paul was hired by the Bechtel Power Corporation to work on their Jim Bridger Power Plant project in the Rock Springs, Wyoming area. Only three months later, he was fired, supposedly because of a reduction in force.

But during the week preceding his discharge, Bechtel hired at least 19 union electricians referred by the local union and retained at least 65 unlicensed electricians.

A determined Paul Robertson filed unfair labor practice charges against the company and the union.

An administrative law judge ruled and was upheld by the full National Labor Relations Board that the union and the employer had indeed discriminated. The judge ordered that Robertson and seven other electricians be given the back pay they would have earned if they had been treated fairly.

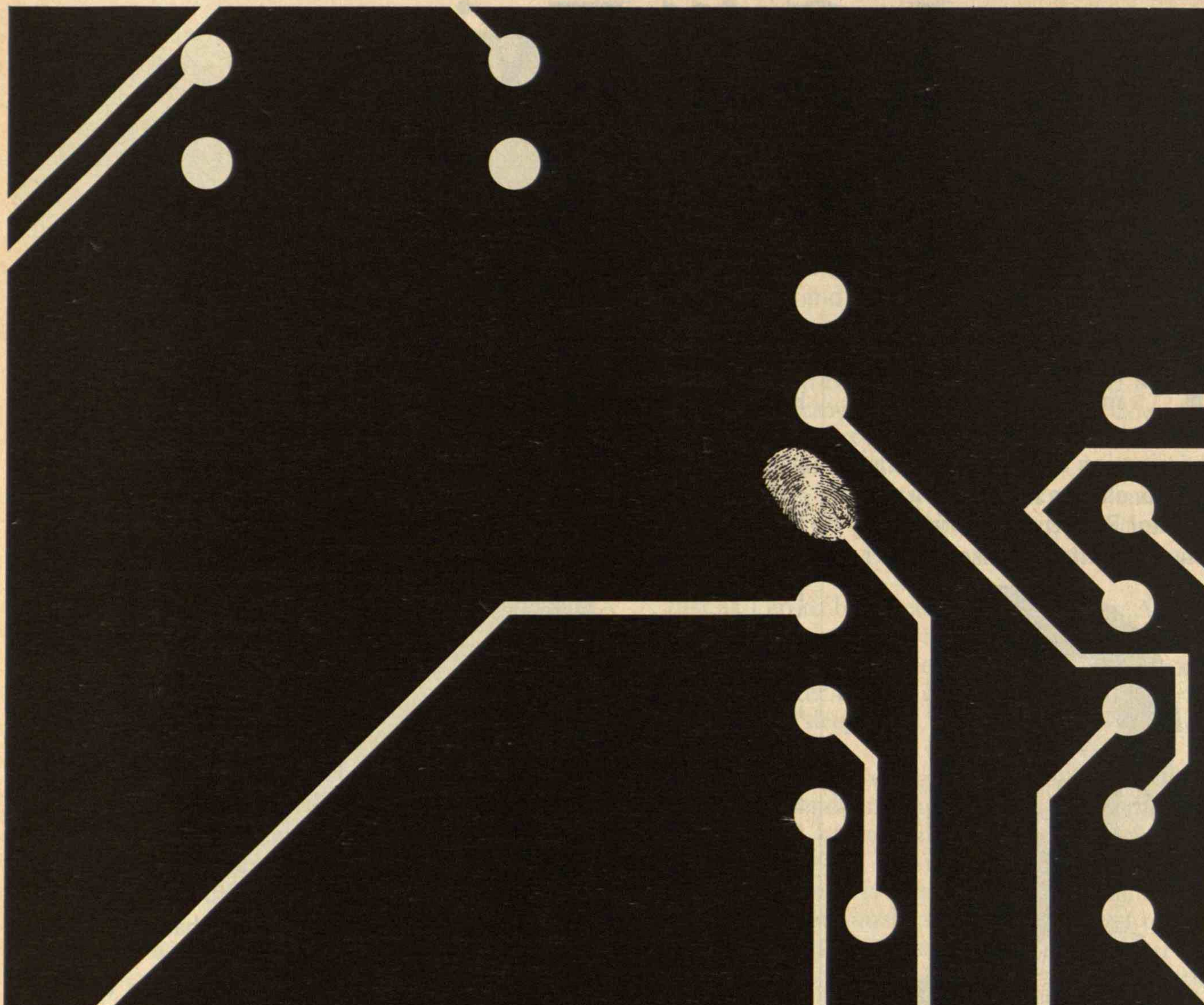
The NLRB later reversed part of its decision, but Paul Robertson did not give up. With the help of the National Right to Work Legal Defense Foundation, he appealed the Board's decision to the U.S. Court of Appeals, arguing that hiring hall favoritism is discriminatory and unlawful.

Paul Robertson was fortunate. He found experienced legal help—all important because the case dragged on for nearly four years in the courts and the union still refuses to obey the NLRB's backpay order.

The National Right to Work Legal Defense Foundation is helping everyone it can—currently in more than 75 cases involving academic and political freedom, protection from union violence, and other fundamental rights. But it would like to do even more.

If you'd like to help workers like Paul Robertson write:

The National Right to Work
Legal Defense Foundation
8316 Arlington Boulevard
Suite 500
Fairfax, Virginia 22038



Illustrations: Bernie La Casse

Subjectivity and Science: A Correspondence About Belief

by Vince Taylor

A student (who shall remain anonymous) recently wrote to criticize my work on the economics of uranium and plutonium. Underlying the criticism were a number of implicit premises about science, research, and policy formulation that are accepted without question not only by this student but by many others who deal with subjects where science and human affairs overlap; thus the following reply is really directed to a large class of people in hopes of opening the narrow confines of conventional, academic thinking to a broader, richer vision of the world process.

Dear Student:

Ostensibly, you wrote to invite my comments on several points you wished to raise about my writings on the economics of uranium and plutonium fuels. In actuality, you delivered a blanket indictment of my competence and personal integrity in performing research. You assert that my "conclusions are not based on sound economic practice," that my "work shows no knowledge of methods currently available for handling uncertainty in an analytic fashion," that I select methods to "obscure the issues" in order to mask my subjective opinions, that my "own personal feelings, opinions and beliefs dominate . . . my conclusions," that I have turned "*advocate* and the study [of mine] can no longer be considered a scholarly objective treatment." In short, I am incompetent and hopelessly biased.

You say that you are a Ph.D. candidate writing your doctoral thesis on issues associated with the reprocessing of spent nuclear fuel to extract the contained plutonium and uranium, that you consider yourself neutral in the nuclear debate, and that you are trying to analyze as objectively as possible the policy questions surrounding reprocessing. To do this, you intend to employ "decision analysis methods . . . in a risk-benefit approach" to quantify the major factors affecting the national decision on whether or not to reprocess, including in this quantification "the proliferation risks associated with commercial reprocessing."

You are almost certainly going to feel, at least initially, that this letter is a strange and inappropriate non-response to your criticisms. It is so intended. I don't want to argue with you how my papers fit your criteria for goodness, because, as you will see, I don't agree with your criteria. Instead, I'm going to try to help you to see how I approach analysis and why I write as I do.

The way in which you write about your own research objectives as well as about the deficiencies in my work indicates that a vast chasm separates the points from which we view the role of research in understanding the world process — a chasm that will not be easy to bridge. What touched me most in your letter, perhaps because I fully shared your faith at one time, was the implicit belief that scientific, objective analysis is the ultimate tool for solving the problems of the world. As a corollary, you assume that solutions derived from applying the complex, mathematical, highly abstract models currently in vogue in academia must necessarily be superior to those reached using simpler methods.

Having traveled down the same road myself, I have strong feelings about your belief in the superiority of highly quantitative analysis performed within the confines of greatly simplified models of the world process. My own experience has led me to conclude that unquestioning faith in such "scientific, objective analysis" is, perhaps, the greatest obstacle to improving policy research; thus my principle object in writing this letter is to shake your faith in such analysis by pointing out its apparent deficiencies and failures.

Scientific Analysis and Human Processes

Quite obviously, scientific method is a powerful tool for testing hypotheses and thus discriminating between alternative explanations for some phenomena. This method has given man great power to manipulate aspects of his environment. The application of scientific principles to industrial production has greatly increased the output of all kinds of goods and services. But as the world's ability to produce material wealth has grown, so also have its political, economic, and human problems. Since science has proven so successful in manipulating the physical world, it is not surprising that society has turned heavily toward science for guidance in dealing with these problems. The type of policy analysis which both of us are doing is part of this effort. But, so far, if measured by its achievements, this effort must be counted a total failure. Problems of unemployment, alienation, family breakdown, crime, urban decay, etc., continue to proliferate in spite of the best policy advice science has to offer.

Policy analysis is failing because its practitioners do not understand the processes they are modeling and analyzing. Scientific method has yielded great success in physical sciences because it is possible for scientists to make repeated experiments under precise conditions, varying only selected parameters. Living organisms are more intractable. Although techniques of statistical analysis can help experimenters to guess about the effects of uncontrolled variables, the power of science has proven to be far less in medicine than in, for example, electronics. When I was studying medical care in the mid–1960s, I was surprised to find that life expectancies for adults had hardly changed since the early 1950s, and for adult males of some ages they had actually declined. This occurred during the great flowering of the National Institutes of Health, when billions were poured into scientific medical research.

In analyzing complex, real-world processes that involve human behavior, scientific analysis has proven to be extremely limited. One need look no further than a review of past predictions of nuclear-electricity costs and nuclear power growth to see how badly scientific method can fail: since the mid-sixties, estimates of the cost of nuclear electricity have risen sevenfold, more than tripling after adjustment for general inflation. Just since 1973, official U.S. government forecasts of installed nuclear capacity in 1985 and 2000 have decreased to one-third their former level.

An outstanding example of erroneous estimation is in our common field of the economics of spent-fuel reprocessing. In the "Draft Generic Environmental Statement on Mixed Oxide Fuel," issued in August, 1974, analysts of the Atomic Energy Commission used $30 per kilogram as their best estimate of likely costs of reprocessing nuclear fuel. Today, estimates range well above $300 per kilogram; after allowing for general monetary inflation, these projections have risen by over 700 per cent in only a few years! Such gross mis-estimation shows a serious lack of understanding of the realities of bringing a large-scale reprocessing plant into actual operation. Don't these enormous errors by supposedly competent analysts create in you any tinge of doubt about the efficacy of scientific analysis in public policy formulation?

Analyses of real-world processes are subject to such catastrophic failures because, in order to reduce analysis to manageable proportions, analysts ignore (or assume to be fixed or to vary as in the past) a multitude of integral aspects of the real-world process being studied. Conceptually, analysis removes a piece of the world process, isolates it, and sees how this isolated piece responds when parts of it are changed. From the information so derived, the

We're looking for engineers who can't wait to get to work.

We're looking for people who are looking for a real job. One that offers challenging work. Responsible work.

That's what you can expect at General Electric.

At GE, you'll be handed important assignments right from the start. You can do as much of the job as you're capable of doing. If you need help, it's there. If not, nobody butts in.

Here's the kind of thing we're talking about; some recent examples of jobs handled by new GE engineers:

1. *Charles P.* Aerospace systems manufacturing. Develop and document a direct numerical control system.
2. *Steve O.* Design engineering. Design test equipment for attitude control system of new communications satellite.
3. *Norma L.* Steam-turbine manufacturing. Investigate, analyze and obtain funds for solution of shop problems.
4. *Stephanie B.* Medical systems service engineering. Installation and test of new hospital radiographic and fluoroscopic x-ray system.
5. *Mel D.* Field engineering. Appraisal load testing of low and medium-voltage switchgear and power transformers for utility and industrial applications.

There's a good reason GE hands people like that—like you—real work assignments. It's the best way to develop the skills you will need throughout your career. You develop initiative and creativity. And responsibility. And GE also knows there's little to match the glow you feel when you make an important contribution.

You can make your contribution in just about any field of engineering at GE. We're that diversified in disciplines.

If you like the kind of challenge and responsibility that GE offers, we'd like to hear from you. Send for our free careers booklet. Just write: General Electric, Educational Communications, WID, Fairfield, Connecticut 06431.

Progress for People

GENERAL ELECTRIC

An Equal Opportunity Employer

Weather Radar Comes to Television

Although weather forecasting is still an art as well as a science, a new technological aid has pushed the balance of short-range forecasting for radio and television well into the realm of science.

Radar transmits short, intense pulses of electromagnetic energy and receives back a fraction of this energy as reflected from various targets in the distance. It was an invaluable tool in World War II for locating such targets as aircraft and tall buildings, and even before World War II the same principle had been applied to locating areas of rainfall. Since then, radar meteorology has become a science from which much has been learned about the nature of storms and the precipitation associated with them.

Now, with the aid of computers, this science is coming into every home in the form of colored rainfall maps used by television weather forecasters. The computer interpreting weather radar images for television distinguishes between precipitation and interfering ground clutter. It assigns different colors to different intensities of precipitation, compensating for the attenuation of echoes from distant rainfall; therefore, all precipitation is shown with its true density. It distinguishes between particles of rain and fog: the energy reflected by a particle is proportional to the cube of its diameter (for example, a raindrop is about 100 times as large as a cloud droplet, so the echo is about 1,000,000 times as strong); and it distinguishes between rain and snow because water has a much higher index of refraction than ice, reflecting energy five times as well (when snow changes to rain, for example, the echo suddenly increases, so the snow/rain line of a storm shows up as a distinct band).

The range of radar is about 250 kilometers, so this color radar system is very useful in forecasting weather for the next three to six hours. Dick Albert, meteorologist of WCVB-TV, Boston, says that his viewers need only glance at the color radar picture on their screens to have "a whole picture of what is happening." Especially during New England winters, he says, "it is very helpful for people to know when a heavy band of snow or rain is coming." — *Crystal Barker, '79* □

What do U.S. scientists who were participants think about the U.S.-U.S.S.R. scientific exchanges between 1959 and 1977? As chairman of a panel of the National Academy of Sciences, Karl Kaysen, David W. Skinner Professor of Political Economy at M.I.T., asked the questions of 350 American scientists; 80 per cent replied, and their answers are tabulated (in per cents) below by Lauren R. Graham, professor of the history of science at M.I.T., in article for *Science* Magazine. (Chart: *Science*, October 27, 1978)

A. Overall, how would you rate your experience in the USSR?

1. Outstanding	(32.4)
2. Very good	(42.3)
3. Satisfactory	(18.8)
4. Fair	(4.8)
5. Poor	(1.8)

B. Please indicate the extent to which you agree or disagree with each of the following statements concerning the scientific nature of the exchange:

	Strongly agree	Agree	Disagree	Strongly disagree
1. Scientifically, the US gains a lot by individual exchanges to the Soviet Union	(13.7)	(44.9)	(35.9)	(5.5)
2. The exchange program results in little new scientific knowledge	(3.2)	(32.4)	(50.2)	(14.2)
3. I was able to gain access to the best facilities the USSR has to offer my field	(20.3)	(53.4)	(20.3)	(6.0)
4. Because the Soviet Union is not very advanced in my field, little scientific benefit for the US results from the exchange program	(7.6)	(13.3)	(47.7)	(31.4)
5. The scientific productivity of the exchange is hampered by the political situation in the Soviet Union	(25.4)	(47.3)	(24.2)	(3.1)

U.S./U.S.S.R. Exchanges: Political as Well as Scientific Benefits

Last May Soviet high-energy physicist Yuri Orlov was sentenced to seven years in prison and five years of internal exile for slandering the Soviet state. He was not allowed to call witnesses in his own defense at his trial.

On a visit to Russia last summer Eli Yablanovitch was invited by Jewish scientists to attend a special scientific seminar. He and his American colleagues were urged by their official scientists-hosts not to attend.

American scientists have reacted strongly to these and other incidents of discrimination perpetrated by the Soviet government against its dissidents. Some American scientists have protested by refusing to participate in scientific exchanges between the United States and the Soviet Union. Now Americans are beginning to question the value of the programs.

Loren R. Graham, professor of the history of science and technology at M.I.T., has asked American participants in the exchanges under the bilateral U.S.-U.S.S.R. agreements between 1972 and 1977 about the value of their experiences and the quality of the Soviet participants.

On the basis of their responses, Professor Graham concludes that American participants are "fairly positive about the value of the program, with three-quarters of them rating their experience in the Soviet Union as outstanding or very good. Most of them believe that the exchange program is of definite value, scientifically speaking, to the United States. On the other hand, these participants are aware of the existence of political controls over science in the Soviet Union and believe that the exchanges suffer because of these controls.

"Soviet science is a heterogeneous collection of disciplines and fields in which the levels of achievement and competence vary widely," Professor Graham writes in *Science (October 27)*. "In a few areas, such as mathematics, some aspects of theoretical physics, and several subfields of engineering, Soviet scientists and engineers are equal to the very best in the world, and cooperation between the United States and the Soviet Union should be equally attractive to both."

Professor Graham suggests two ways to

What about the capabilities of the Soviet scientists who came to the U.S. on scientific exchange missions between 1972 and 1977? Professor Karl Kaysen (see opposite) asked 150 American who were the Soviets' hosts; 80 per cent replied, and their answers (also in per cents) are shown below. Analyzing these findings in *Science*, M.I.T. Professor Loren G. Graham concluded that the American hosts were "restrained in their enthusiasm for Soviet science, probably more so than the exchange participants." (Chart: *Science*, October 27, 1978)

A. All told, how well did this visitor rate against other scientists you have known at comparable stages in their careers?

Compared to:	American scientists	Visiting scientists from other countries
He was better	(10.2)	(25.0)
About the same	(57.4)	(55.8)
He was weaker	(32.4)	(19.2)

B. Do you feel that you and your institution benefitted from this scientist's visit?
(Yes, 78.9) (No, 20.2) (No response or don't know, 0.9)

1. If you feel that you and your institution benefitted from this scientist's visit, to what extent do the following statements describe that benefit?

	Strongly agree	Agree	Disagree	Strongly disagree
a. The scientist is an expert in his field: he suggested new research procedures, introduced new ideas or imparted new knowledge	(8.1)	(65.1)	(22.1)	(4.6)
b. Although his training and capabilities were lower than we usually expect of a professional in our field, he contributed to our work on a technical level	(4.8)	(28.3)	(38.5)	(28.3)

make the exchange program more effective: he proposes "joint symposia on selected topics" and collaborative research projects in fundamental science. "We now know much better what the areas of Soviet excellence are, and we should target our efforts toward them," Professor Graham writes.

In an interview, Professor Graham emphasized that "it is a mistake to evaluate the programs only in terms of scientific worth." He thinks they have important potential for guaranteeing human rights in the U.S.S.R. — "the best way of keeping American scientists informed of the plight of their Soviet counterparts." Indeed, writes Professor Graham, "there is much evidence that the awareness of the international community is a contributing factor to Soviet restraint." — *Steven Frann, '80* □

Protein vs. Sickle Cells

An inhibitor for sickle cell anemia may be on the horizon at M.I.T.

Reporting in *Science*, Joseph R. Votano and Professor Alexander Rich of the Department of Biology say they have identified a group of peptides composed of a small number of amino acids which prevent the effect of sickle hemoglobin in a red blood cell.

The compounds can't yet be used therapeutically because they do not pass through a cell membrane and so cannot enter the blood cells. But some of the amino acid residues in the peptides do so, and Drs. Votano and Rich are optimistic that chemical modifications will be possible.

Dietary Supplements for Neurotransmitters

Tardive dyskinesia is a motor disorder which is a frequent side effect of antipsychotic drugs. Now it's found that choline, a chemical common in eggs, meat, and fish, will help control tardive dyskinesia.

Madelyn J. Hirsch and John H. Growdon, working under Professor Richard J. Wurtman in the Department of Nutrition and Food Sicence, think their finding previews new forms of therapy for brain diseases associated with abnormal levels of neurotransmitters — substances secreted by brain cells to carry messages to other brain cells. Choline is a raw material used by the brain in its manufacture of these critical substances. □

The Social Benefits of Remanufacturing

When your washing machine wears out ("This just isn't worth repairing," you're told), you throw it away and get a new one. But there's a "neglected alternative," say Robert T. Lund and William M. Denney of the Center for Policy Alternatives. It's remanufacturing: disassembling machines, replacing worn-out parts and reusing still useful ones, and reassembling them to make products which are virtually as good as new.

Remanufacturing has, in fact, been practiced in some industries. But Messrs. Lund and Denney aren't talking about small-scale unit-by-unit rebuilding; their idea is to foster a "highly organized business" of disassembly and reassembly which would save ever scarcer materials and boost employment. After a Washington conference on the subject in November, Mr. Lund said the idea is "growing like a mushroom. . . . There is excitement in Washington on this, and we may soon see federal encouragement of remanufacturing as a socially beneficial process." □

Observing Neutron Stars

Theory has it that a neutron star forms when a star such as our sun consumes all its nuclear fuel and collapses into a tiny, immensely dense ball perhaps ten miles in diameter. That may be hard to imagine, but two new pieces of evidence from M.I.T. astronomers seem to link theory and observation ever closer.

Such a neutron star would emit bursts of x-rays and would have an immense magnetic field — 1 trillion gauss or more, compared with earth's 0.5 gauss. William R. Wheaton of the Center for Space Research found such a magnetic field around the object 4U0115+63 last summer. And later two of Dr. Wheaton's colleagues, Jeffrey E. McClintock and Claude R. Canizares working with Jonathan E. Grindlay of the Harvard-Smithsonian Center for Astrophysics, correlated an x-ray burst from a presumed neutron star with the brightening of a visible source in the same vicinity. The second observation generated special excitement because it confirmed the idea of x-ray bursts from neutron stars; it is hypothesized that a burst of x-ray energy would cause illumination in a cloud of gas surrounding the neutron stary or would be enough to make a conventional star brighten briefly. □

MANY PEOPLE THINK VERY HIGHLY OF US.

FOR A LOT OF WRONG REASONS.

It might surprise you, but Hughes doesn't make aircraft. What we do has been expressed nicely by our Chairman of the Board, Dr. Allen E. Puckett: "We're involved in a wide range of communications technologies, making sensors that operate on all parts of the electronic spectrum, and computers and signal processors that issue commands or store and present data. In the midst of the dramatic electronic information explosion, Hughes is putting data sensing, communications and data processing advances to work for people like you and me."

If you're an EE, ME, AE, IE, Physics, Material Science or Computer Science major, you could become part of this exciting and challenging commitment. You could become involved in aerospace, ground systems, industrial electronics, space and communications and research. And don't worry about getting lost - at Hughes, we work in small groups where individual initiative is valued highly.

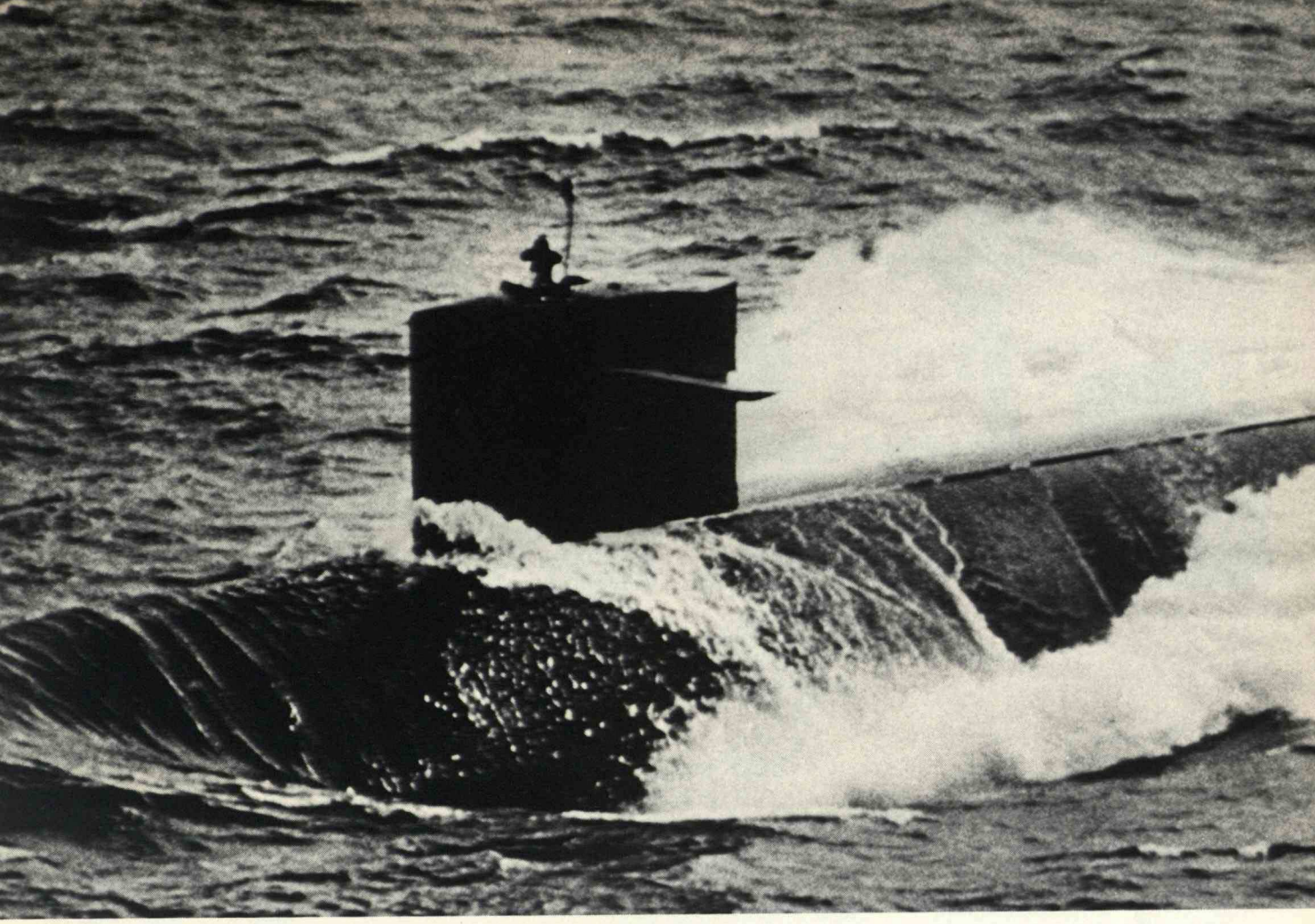
Hughes - for all the right reasons. For details on our opportunities, contact your placement office, or write: Manager, College Relations, Hughes Aircraft Company, P.O. Box 90515, Bldg. 100/445, Los Angeles, CA 90009.

HUGHES

Creating a new world with electronics

An equal opportunity employer, M/F/HC

U S Citizenship required



HERE'S ONE ENGINEERING OPPORTUNITY YOU WON'T GET IN PRIVATE INDUSTRY.

If you're thinking about a technical position after graduation, think about this.

How many companies can offer you a nuclear submarine to operate? The answer is none. Equipment like this is available only in one place – the Navy.

The Navy operates over half the nuclear reactors in America. So our training is the broadest and most comprehensive. We start by giving you a year of advanced technical education. In graduate school, this would cost you thousands, but in the Navy, we pay you.

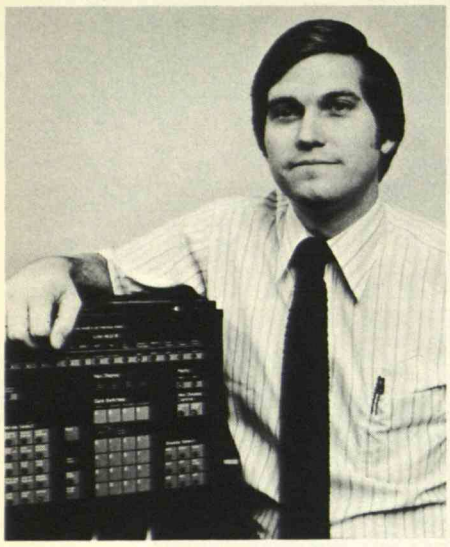
Once you're a commissioned Nuclear Propulsion Officer, you'll earn a top salary. Over $24,000 a year after four years. And you'll be responsible for some of the most advanced equipment developed by man.

The Navy also has other opportunities in surface ships and aviation assignments. If you are majoring in engineering, math or the physical sciences, contact your placement office to find out when a Navy representative will be on campus. Or send your resume to: Navy Officer Programs, Code 312-B626, 4015 Wilson Blvd., Arlington, VA 22203.

The Navy. When it comes to nuclear training, no one can give you a better start.

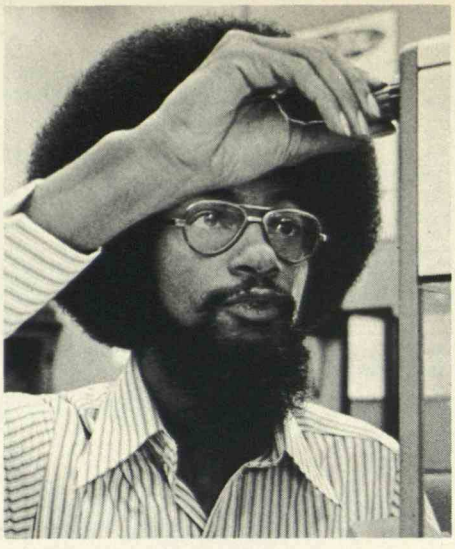
NAVY OFFICER. IT'S NOT JUST A JOB, IT'S AN ADVENTURE.

What's it like to be an engineer at IBM?

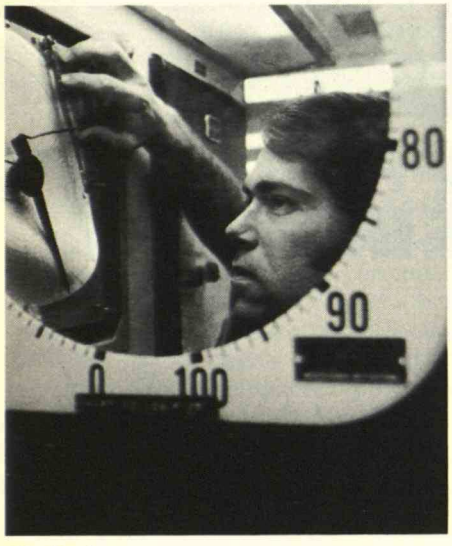


Bill Kleinhofer
BS/Electrical Engineering '72
University of California, Santa Barbara
MS/Electrical Engineering '77
University of California, Santa Barbara
"The technical vitality here at IBM is attractive for young engineers looking for a future."

Evelyn Gratrix
BS/Electrical Engineering '74
University of Washington
"Growth and success in IBM are only limited by an individual's own ambitions and ability."

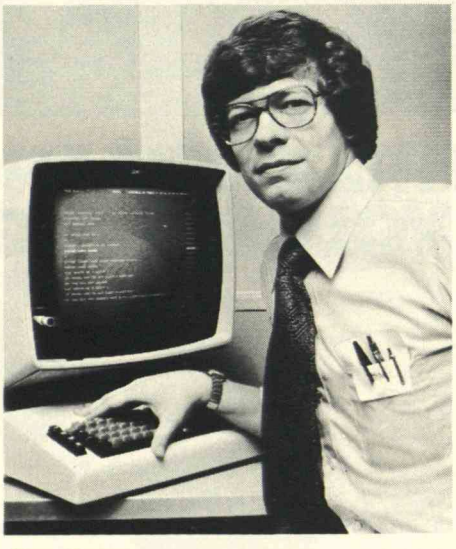


Doug Brooms
MS/Mechanical Engineering '72
Stanford
"The atmosphere is relaxed and informal, quite distinct from the dark suit and tie image of IBM. The people as a whole are congenial and cooperative."



Ric Davis
BS/Mechanical Engineering '68
University of California, Davis
MBA '76, University of Santa Clara
"IBM has provided me with all that I've desired in an engineering career."

Homer Dean
BS/Mechanical Engineering '72
San Diego State
"IBM has elevated my responsibilities as fast as I was willing and able to accept them."



Tony Spear
BS/Electrical Engineering '77
Purdue University
"IBM encourages me to challenge the accepted ways."

If you could talk with some of the engineers who have joined us recently, you'd hear some good reasons for working at IBM. Our people are given responsibility for projects as soon as they can handle it and they have the freedom to carry their projects through to completion. There's a lot of room for personal growth and outstanding opportunity for advancement because we make a practice of promoting from within. If you'd like to know more about a career in engineering, sign up for an interview at the Placement Office, or write:
W.A. Dickert, Corporate College Relations Manager,
IBM Corporation, One Barker Avenue,
White Plains, NY 10601.

IBM®
An Equal Opportunity Employer

We will be interviewing at M.I.T., Friday, February 16.

MIT '79

"The only way to understand or to appreciate rowing is to row," says Cynthia Cole, '78. That's the idea behind Class Day — to give everyone who wants it a sample of M.I.T.'s premier sport, and maybe to hook people on it.

This year's date was November 4 — warm, calm, and foggy, ideal for the purpose. When it was over, 434 rowers from all parts of M.I.T. had been in 54 boats through the 1,000-meter course on the Charles. They learned what Elizabeth A. Fisher, '80, meant when she wrote in The Tech *a week earlier about what rowing is and isn't: ". . . not a frantic struggle against the oar and other oarsmen . . ." but "a calm, coordinated all-as-one movement which gracefully glides the shell through the water," and they also learned "the taste of the speed and the flying feeling you experience when all eight are hitting the catch at the same instant," as Ms. Cole puts it. (Photos: John O. Borland, '81, from* The Tech*)*

Can China Become a New World Power in Science by 2000? Two Travellers Report

A dazzling reversal of official and public attitudes toward science and technology throughout China was reported by two speakers at M.I.T. this fall. But Edward E. David, Jr., Sc.D. '50, and Frank Press both qualified their enthusiasm with some unanswered questions: What will happen if the ambitious goals for Chinese technology turn out to be unrealizable? Or if they bring to China the social problems of labor displacement and class distinction which are elsewhere assigned to the industrial revolution?

Dr. David travelled to China as President-Elect of the American Association for the Advancement of Science early in the fall, Dr. Press as White House Science Adviser; Dr. Press was in fact the leader of a delegation comprising every major U.S. presidential appointment in the field of science and technology — the "highest level scientific and technological group the U.S. has ever sent to a foreign country," he said. Both visitors reported an extraordinarily warm reception for themselves and for science in China: the Chinese "held back nothing," thinks Dr. David, and they embraced their American visitors as the source of new knowledge which they desperately seek.

Their talk of the nation's needs, and of the way a generation of scientists and engineers was wasted by the repression of the 1960s, was "blunt and honest," Dr. Press reported.

"A 180° Change of Course"

Four objectives are stated by the Chinese for their new thrust in science and technology: modernize agriculture, strengthen defense, develop industry, and achieve maturity for their own science and engineering. These objectives are taken to embrace literally everything: high-energy physics, computers, space science, laser technology, energy resources, genetics, automation . . .

In less than a decade, the Chinese told Dr. David, they want their technology to be as strong as ours was in the early 1970s; the goal by the year 2000 is to be "competitive with the world" in science, according to Dr. Press.

The goals seem to both Dr. David and Dr. Press to be unrealistic; but both found the Chinese determined to have them taken seriously: "an extraordinary new philosophical thrust" now supports science in China, said Dr. Press, a "180° change of course" from the days of the "gang of four." There is "pride in basic research, new optimism for what the nation can do to modernize itself," he said. The Chinese are moving quickly into the "international scientific arena" — attending meetings, sending students abroad, and opening their doors to foreign visitors and students. Their borders are open to

While M.I.T. was hearing about the renaissance of science in China from Edward E. David, Jr., Sc.D. '50, and Frank Press (see story, left), it was experiencing the results this winter in the form of a growing invasion of visitors from the People's Republic. The picture shows Charles C. Benton (left), a graduate student in architecture who was a co-designer of M.I.T.'s solar house, describing it to a group of Chinese architects; among them was Ho Kuang-Tsien, Acting President of the Architectural Society of China. (Photo: Calvin Campbell)

western capital — including such capitalistic instruments as equity investments. A resource of perhaps 800,000 researchers are now restored to their laboratories and hard at work. Tentative plans are now being made for American students going to China, including at least one from M.I.T. *(see left),* and the Chinese talked to Dr. Press about sending as many as 10,000 students a year to western universities by 1985.

"The New China Pajama Game"

Chinese goals imply enormous expenditures for technical development, and capital will not be easy to find. But as of today, the Chinese have no foreign debt and a modest surplus of foreign currency and the potential exists for exports of oil and mineral resources.

Consider the case of what Dr. Press called "the new China pajama game": the Japanese have installed a complete new pajama factory in China, and their investment will be returned in the form of pajamas imported from the new factory. Already the Chinese have contracted for U.S. machinery for an entirely new coal mine, and they talked to Dr. Press about a satellite to provide modern communications for the sprawling nation and a nuclear power plant to be installed within two years.

"An Enormous Amount to Contribute"

No one doubts that the Chinese view of their goals and future is unrealistic and oversimplified. But Dr. Press insisted that the changes are real and sincere. "Enormous numbers" of Chinese embrace them, and "I don't think they can turn back," Dr. Press said.

Dr. Press and his boss, President Jimmy Carter, are convinced that "a stable China is important to world stability" and that new strength in science and engineering will help turn China into a modern world power. He wants to avoid giving China technology that will be useful for offensive military operations, and he thinks that strengthening China is the best way to assure increasing civil rights for all Chinese.

More than that, he thinks international science can only gain from the new Chinese thrust. They have "an enormous amount to contribute. It doesn't matter if an American or a Chinese finds a cure for cancer," Dr. Press said, "the whole world will be better for it." And China presents a unique opportunity for "the world's largest experiment in birth control," since its population is now stable at about 900 million.

But haunting questions remain. Can a nation change so fast? Can such rapid change be achieved with political and economic stability? Contemplating these, Dr. David (he spoke to the Corporation luncheon on December 1) recalled the poignant (if unanswerable) question from a Chinese host: "How will we know when we have achieved an advanced society?" he was asked.

Meeting China in the Schools: "An Enormous Intellectual Reserve"

What role will colleges and universities play in the new relationship between the United States and the People's Republic of China?

As the formal obstacles to fruitful relations between Chinese and U.S. scholars vanish, there will still be some problems — but these are "positive problems," says Walter A. Rosenblith, M.I.T. Provost and Institute Professor. He spoke this January at a symposium on "A New Era in U.S.-China Relations," sponsored jointly by the Boston Chapter of the National Association of Chinese-Americans and the Center for International Studies at M.I.T.

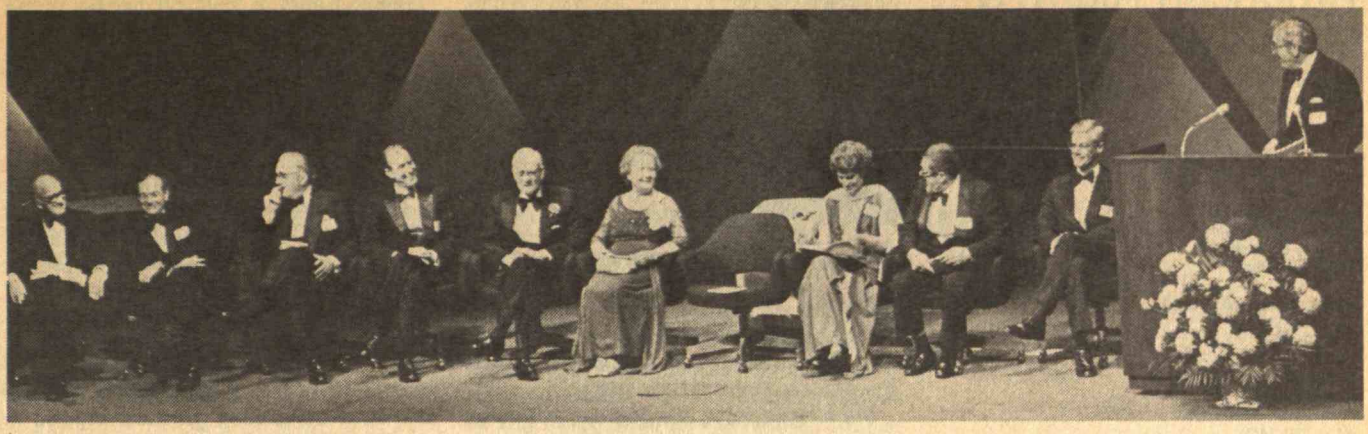
Traveling from one country to another, scientists can be assured that the laws of nature are constant, but "institutions of higher education certainly are not," said Professor Rosenblith. "How do you get these things matched? How do you bring people together in such a way that what is learned here can be not copied but transferred and translated into new realities? And how will we fit into the emerging philosophy of education in the People's Republic of China?"

Professor Rosenblith thinks it's going to be difficult to define the prerequisites for participants in a successful U.S.-China educational exchange. For example, students need more than an acquaintance with the language of their host country — they require mastery of the language's technical vocabulary for their field. "We should match up competences," he says — "and we should probably start at a fairly advanced level. It is a great deal more difficult for foreigners to fit in at the undergraduate level than at the level where they have made a commitment to a particular field."

Because of China's recent history, says Professor Rosenblith, "a lot of people had never really become embedded into the structure of the university"; they are "an enormous intellectual reserve — if they make the kind of connections that institutions like M.I.T. have to offer they can then go back and build their own institutions in a very effective way."

Professor Rosenblith said that M.I.T.'s other overseas connections — in Berlin, Calcutta, Singapore, and Cairo — were rewarding because "we did not try in a mechanical fashion to translate what we were doing here; we did not try to 'license' the name or method of M.I.T." Instead, the Institute's philosophy was adapted and evolved for different needs.

"I don't want it to seem uneven," he said. "We must get the right kind of people here; and, I hope, the reverse — I'm happy to see that at least one of our students [Lucille M. Jones, a graduate student in Earth and Planetary Sciences, who was in the symposium audience] is going to the People's Republic in the first exchange."



Creative International Philanthropy — and a "Towering Friendship to Students Everywhere"

Cecil H. Green, '23, and his wife Ida have literally changed the face of the English-speaking world by their generous and far-sighted philanthropy, and to show their thanks the presidents and chancellors of more than 30 colleges, hospitals, museums, schools, scientific associations, and universities in Australia, Canada, England, and the U.S. joined in an international tribute in the Great Hall, Refectory, and Auditorium of the National Academy of Sciences in Washington on November 9.

Trained in electrical engineering at M.I.T., Mr. Green was part of a group of exploration geologists who organized Geophysical Service, Inc., as a private, independent company in 1941 and which later founded Texas Instruments, Inc., in 1945. Throughout this period Mr. and Mrs. Green maintained a close partnership and an innovative approach to personal relationships, and they later carried this forward to philanthropy, with a result that they have together endowed and become closely involved with:

☐ Fifteen major university or hospital facilities.

☐ Twenty fully-endowed professorships, mostly in the sciences and engineering.

☐ Fellowships to encourage women students in science and engineering at three universities and a medical center.

☐ A Master Teacher Chair, held by a first-grade teacher at St. Mark's School of Texas in Dallas.

☐ A 275–ton ocean-going research vessel.

☐ An educational television system.

☐ A global system of earthquake detectors including 14 stations (soon to be 20).

In a printed statement, the participating institutions said the purpose of their tribute was "to recognize the towering friendship which Cecil and Ida Green have given to students everywhere by dedicating their lives to advances in science, medicine, technology and basic improvements in the quality of education. At a time when the Greens have already been recognized individually by the many institutions they have served, this combined tribute has significant historic value in the annals of private giving to education, and it represents a unique, international expression of affection and appreciation by the grateful recipients of their support."

A stage-full of luminaries honored Cecil H. Green, '23, and his wife Ida at the National Academy of Sciences in Washington on November 9 for their dedication "to advances in science, medicine, technology, and the basic improvements in the quality of education." Left to right in the picture are Philip Handler, President of the National Academy of Sciences; Frank Press, Director of the Office of Science and Technology Policy in the White House; Allan Shivers, Chairman of the Board of Regents of the University of Texas System; Peter S. Bing, President of the Board of Trustees of Stanford University; Dr. and Mrs. Green; Marjorie Bell Chambers, President of the American Association of University Women; Henry Messel, Head of the School of Physics at the University of Sydney, Australia; Charles A. LeMaistre, President of the University of Texas System Cancer Center; and (at the rostrum) Jerome B. Wiesner, President of M.I.T.

F. D. Massie

Financial Aid Appointment

Frederick D. Massie, formerly Associate Director of Financial Aid at Brown University, has joined M.I.T. in a similar capacity in the Student Financial Aid Office.

Mr. Massie holds two degrees in English and education from Brown, and he was associated with Brown's financial aid programs from 1963 until coming to M.I.T. late last year. Jack H. Frailey, '44, director of student financial aid, says Mr. Massie's assignment will be to provide financial counseling to graduate and undergraduate students and to administer financial aid through loans and scholarships from federal and university funds.

Individuals Noteworthy

Plasma Fusion Appointments

Four new associate directors have been named in the Plasma Fusion Center, where more than 150 scientists and engineers are working on fusion power development:

☐ Professor **Lawrence M. Lidsky** of the Department of Nuclear Engineering, who heads P.F.C.'s Technology Development Division.

☐ **D. Bruce Montgomery,** '56, Associate Director of the Francis Bitter National Magnet Laboratory, who heads the Engineering Division.

☐ Professor **Ronald R. Parker,** Sc.D. '67, of the Department of Electrical Engineering and Computer Science, who heads the Confinement Experiments Division.

☐ Professor **Ronald C. Davidson** of the Department of Physics, who is Acting Head of the Applied Physics Research Division.

Daniel R. Cohn, Ph.D. '71, has been named to head the Center's Office of Planning and Advanced Projects.

National Magnet Laboratory Promotions

Three new Associate Directors of the Bitter National Magnet Laboratory: **Roshan L. Aggarwal,** a member of the Laboratory's Quantum Optics and Plasma Physics Group, to be responsible for administration of National Science Foundation programs . . . **D. Bruce Montgomery,** '57, Leader of the Magnet Research and Technology Group, to lead the development of high-field magnets for the National Science Foundation, Department of Energy, and Plasma Fusion Center . . . **Ronald D. Parker,** Sc.D. '67, who is also Professor of Electrical Engineering, to correlate Magnet Laboratory efforts for the Plasma Fusion Center.

Simon Foner, a founding member of the Bitter National Magnet Laboratory who heads its Magnetism and Superconductivity Group, is now Chief Scientist.

M.I.T. Changes

Donna R. Savicki, Assistant to the Director of the Innovation Center, to Administrative Officer of the Department of Aeronautics and Astronautics . . . **Robert L. Kehner,** library staff member, to Assistant Librarian for Documents in the Dewey Library.

Roger A. Samuel, '66, returned to M.I.T. late in the fall as Industrial Liaison Officer; he had joined Boeing Commercial Airplane Co. upon completing graduate studies in civil engineering (C.E. 1969) at the Institute, working in the field of stress analysis. . . . **Kathleen A. Powers,** formerly reference and interlibrary loan librarian in the Bapst Library at Boston College, is now Associate Humanities Librarian; she's a graduate of Boston College and the Columbia University School of Library Service.

Honors at M.I.T.

To **Frank A. McClintock,** professor in the Department of Mechanical Engineering, the Nadai Award by the American Society of Mechanical Engineers.

Donlyn Lyndon, Professor of Architecture and chairman of the Committee on the Visual Arts, elected to the College of Fellows of the American Institute of Architects . . . Three M.I.T. faculty members are among the recipients of the Guggenheim Fellowships in 1978: **Cyril Stanley Smith,** Professor Emeritus; **Martin Rein,** Professor in the Department of Urban Studies and Planning; **Langley C. Keyes, Jr.,** head of the Department of Urban Studies and Planning.

Wayne Andersen, Professor in the Department of Architecture, has designed a sculpture site on the grounds of Clark University in Worcester, where a sculpture in memory of Robert Goddard will be installed. . . . **Charles Batterman,** Associate Professor in the Athletics Department, was presented the Fred Cady Memorial Diving Award. He was also inducted into the Swimming Hall of Fame. . . . **George W. Rathjens,** Professor of Political Science, member of a newly formed study group to compare the energy options in the United States over the next 20 years, financed by a $600,000 grant from the Ford Foundation. . . . **Jack L. Kerrebrock,** Professor of Aeronautics and Astronautics, elected member of the National Academy of Engineering.

I.E.E.E. Awards

Four major awards to members of the M.I.T. community from the Institute of Electrical and Electronics Engineers during Electro '78 in Boston: the Medal of Honor to **Robert N. Noyce,** Ph.D. '53, "for his contributions to the silicon integrated circuit, a cor-

nerstone of modern electronics," ... the Edison Medal to **Daniel E. Noble,** '38, "for leadership and innovation in meeting important public needs ... in mobile communications and solid-state electronics," ... the Founders Medal to **Donald G. Fink,** '33, Director Emeritus of I.E.E.E., "for contributions and leadership in television, radar, and technical journalism and service to the electrical and electronics engineering profession," ... and the Lamme Medal to **Harry W. Mergler,** '45, "for pioneering research and creative industrial application of digital technology to machine tool and industrial control systems."

R.T.C.A. Citation

To **Chen-Chung Hsin,** Ph.D. '76, now a member of the technical staff at Mitre Corp., the William E. Jackson Award of the Radio Technical Commission for Aeronautics for "outstanding work" in thesis research at M.I.T.

On Our Bookshelf

M. David Egan, S.M. '61, *Concepts in Building Firesafety,* John Wiley and Sons. ... **Paul Schindler,** Jr., '74, *Aspirin Therapy,* Walker and Co.

Kudos: Honors, Awards, Citations

To **Edward A. Mason,** Sc.D. '48, vice president of research at Standard Oil Co., the Robert E. Wilson Award for outstanding contributions and achievements in the nuclear industry ... to **Robert R. Freeman,** S.M. '59, deputy director of the National Oceanic and Atmospheric Administration's Environmental Science Information Center, the Department of Commerce's Silver Medal ... to **Ernest D. Strait,** '55, the Legion of Merit ... to **George P. Palo,** '28, the Rickey Medal from the American Society of Civil Engineers.

To **Philip La-Fan Liu,** Ph.D. '74, assistant professor of civil and environmental engineering at Cornell University, the Walter L. Huber Civil Engineering Research Prize ... to **Ronald S. Newbower,** '65, director of the Bioengineering Unit of the Harvard Anesthesia Center of the Massachusetts General Hospital, the Arnold O. Beckman Award ... **Garth Coombs,** '51, research manager at the Johns-Manville Sales Corp., named a fellow of the American Institute of Chemical Engineers ... to **William H. Mueser,** '22, an honorary membership in the American Society of Civil Engineers, the Society's highest award.

To **John T. Christian,** Ph.D. '57, consulting engineer with Stone and Webster Engineering Corp., the American Society of Civil Engineers News Correspondent Award ... to **Anthony D. Kurtz,** Sc.D. '51, president of Kulite Semiconductor Produts, the Si Flour Technology Award ... to **John A. Brown,** S.M. '57, National Weather Service meteorologist, the annual Engineering and Applications Development Award of the Commerce Department's National Oceanic and Atmospheric Administration ... to **John Clark Chato,** Ph.D. '60, professor of mechanical and bioengineering at the University of Illinois, the American Society of Mechanical Engineers's Charles Russ Richards Memorial Award.

The Ford Foundation announces a grant to Resources for the Future to conduct a major study comparing coal with other energy options available to the United States over the next 20 years. Three M.I.T. alumni are members of the study group of 20 scientists and scholars: **Francis M. Bator,** '49, Professor, Kennedy School of Government at Harvard University; **S. William Gouse,** '53, Chief Scientist of MITRE Corp.; **Theodore B. Taylor,** '63, Adjunct Professor, Princeton University and Solar Energy Consultant.

George E. Power, '41, research director of Formica Corp., the Scientific Achievement award for his scientific contributions in the development of new resin chemistry processes. ... **Robert D. Maurer,** Ph.D. '51, manager of applied physics research at Corning Glass Works, the American Institute of Physics' first prize for Industrial Applications of Physics for "contributions made to the practical application of optical communications through the understanding and discovery of materials and techniques for the fabrication of glass fiber waveguides." ... **Patrick J. McGovern,** '59, of International Data Group, Inc., membership in the Young Presidents' Organization, Inc. ... **Stephen A. Kliment,** '53, of New York City, chairman of the Advisory Council at the Princeton University School of Architecture and Urban Planning, elected to the College of Fellows of the American Institute of Architects.

To **Charles W. Rogers,** '58, the Meritorious Service Medal for outstanding duty and performance as chief ... to **C. Fayette Taylor,** '29, Professor Emeritus of M.I.T., fellow of the Society of Automotive Engineers ... **David Epstein,** Sc.D. '49, Professor of Music and conductor of the M.I.T Symphony had "Five Scenes," composed by Professor Epstein, featured in concert by the Master Singers of Lexington.

Elected members of the National Academy of Engineering: **David Brown,** S.M. '40, Halcon International, Inc.; **Robert L. Coble,** Sc.D. '55, Professor of Materials Science and Engineering at M.I.T.; **Andrew F. Corry,** '44, Boston Edison Co.; **James L. Flanagan,** Sc.D. '50, Bell Laboratories; **J. Earl Frazier,** '24, Frazier-Simplex, Inc.; **George N. Hatsopoulos,** '49, Thermo Electron Corp.; **William W. Lang,** S.M. '49, I.B.M. Corp.; **William J. LeMessurier,** S.M. '53, Sippican Consultants International, Inc.; **Walter G. May,** Sc.D. '49, Exxon Research and Engineering Co.; **Russell G. Meyerand, Jr.,** '55, United Technologies Research Center; **Harold S. Mickley,** Sc.D. '46, Stauffer Chemical Co.; **Walter E. Morrow, Jr.,** '49, Director of the Lincoln Laboratory; **William H. Mueser,** '22, of Bedford Village, N.Y.; **Nathan E. Promisel,** '29,

consultant of Silver Spring, Md.; **Lawrence G. Roberts,** '59, Telenet Communications Corp.; **Kenneth A. Roe,** '41, Burns and Roe, Inc.; **Alexander C. Scordelis,** S.M. '49, University of California, Berkeley. **John E. Steiner,** S.M. '41, The Boeing Co.; **George W. Swenson,** S.M. '48, University of Illinois at Urbana-Champaign; **Andrew J. Viterbi,** '56, Linkabit Corp. Elected foreign associates: **Peter V. Danckwerts,** S.M. '48, University of Cambridge, England; **Leonardo Zeevaert,** S.M. '40, consultant, Mexico City.

Counselors: Officers, Directors, Advisors

Daniel R. Lynch, S.M. '71, joins the faculty of the Thayer School of Engineering. . . . **John F. Maxwell,** '52, named chairman of the Department of Continuing Education in Business and Management at University of California Extension at Berkeley. . . . **Robert G. Dettmer,** '55, vice president of financial management and planning for PepsiCo, elected a director of the Pantasote Co.

Roger M. Freeman, Jr., '44, president of Allendale Mutual Insurance Co., elected a member of Bryant College's Board of Trustees. . . . **Bernard Shapiro,** S.M. '58, chairman of the mathematics department of the University of Lowell.

Paul E. Gray, '54, M.I.T. Chancellor, elected to the board of directors of Arthur D. Little, Inc. . . . **Mark B. Schupack,** '53, professor of economics, appointed associate dean of the faculty and academic affairs at Brown University. . . . **Alexander V. D'Arbeloff,** '49, President of Teradyne, Inc., elected a trustee of New England Conservatory of Music. . . . **Philip D. Shutler,** S.M. '64, promoted to lieutenant general and assigned as Director, J–3, Joint Chiefs of Staff, at the Pentagon.

Three alumni appointed to faculty at M.I.T.: **H. Robert Horvitz,** '68, to assistant professor in the Department of Biology; **David A. Vogan,** Ph.D. '76, to assistant professor in the Department of Mathematics; **Sy David Friedman,** Ph.D. '76, to assistant professor in the Department of Mathematics. . . . **Jack Flipse,** '42, professor at Texas A and M University, formerly president of Deepsea Ventures, Inc., was a speaker at the Law of the Sea Conference in Geneva, Switzerland.

John P. Renshaw, '39, president of Van Strum and Towne, Inc., elected a member of the board of directors of the American Council for Capital Formation. . . . **John R. Mather,** '47, chairperson and professor of geography at the University of Delaware, appointed Delaware state climatologist. . . . **Aaron L. Brody,** '51, New Ventures manager at Mead Packaging, named vice president, Public Affairs and chairman of the Public Affairs Force of the Packaging Institute, U.S.A.

Joseph I. Goldstein, '60, professor of Metallurgy at Lehigh University, appointed director of Materials Research Center's new electron optical laboratory at Lehigh. . . . **Donald M. Davis,** '67, promoted to associate professor of mathematics and granted tenure at Lehigh University. . . . **R. Stanley Bair,** '50, owner of the architectural firm R. S. Bair and Associates in Houston, appointed President of The Construction Specifications Institute.

Robert I. Price, N.E. '53, promoted to Commander, Coast Guard Atlantic Area with rank of Vice Admiral, U.S.C.G. . . . **Richard Rush,** '67, visiting assistant professor at Carnegie-Mellon University, named an associate editor of *Progressive Architecture*. . . . The National Academy of Engineering announces the election of **W. Kenneth Davis,** '40, vice president at Bechtel Power Corp., to vice president; **Frederic A. L. Holloway,** Sc.D. '39, vice president-science and technology at Exxon Corp., re-elected treasurer.

Rising and Changing in Business

Eugene D. Scalera, '52, previously president of the Singer Co.'s Climate Control Division, has joined the General Tire and Rubber Co.'s Chemical Plastics Division as a vice president. . . . **Louis B. Heaton,** '38, elected senior vice president of the New Hampshire Insurance Co. . . . **Theron E. Bastian,** '57, appointed to general manager of Carborandum Irrigation Systems. . . . **Jerome H. Goldberg,** S.M. '60, senior construction manager of Stone and Webster, elected a vice president.

James R. Taggart, '69, promoted to assistant director of software for Functional Automation. . . . **A. Thomas Young,** S.M. '72, director of the Planetary Program in N.A.S.A.'s Office of Space Science, named deputy director of N.A.S.A.'s Ames Research Center. . . . **Horace Robson,** '47, appointed manager of Air and Water Resources at Union Camp Corp.

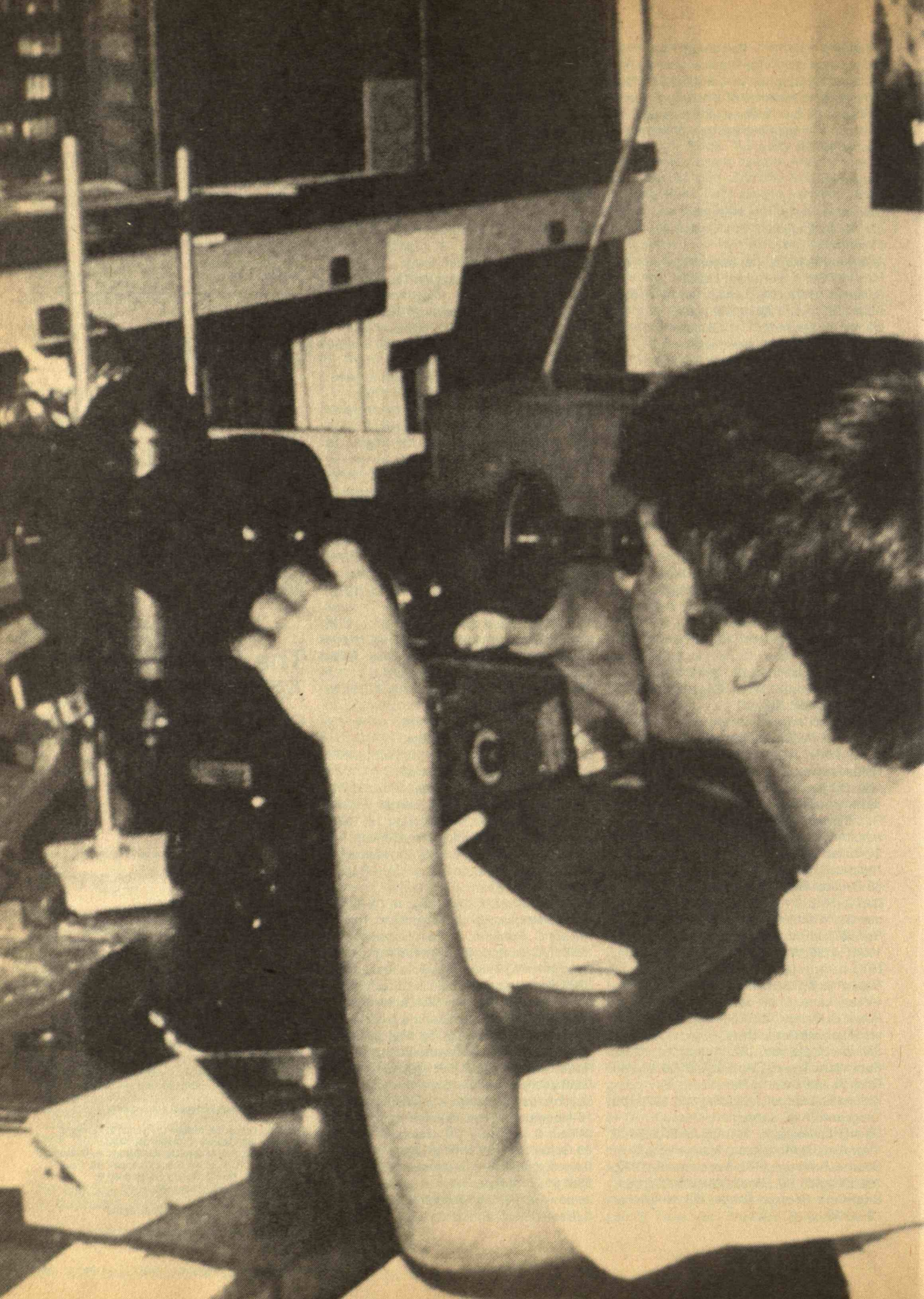
John J. (Jay) Wetzel II, SL '73, a staff engineer for engine emissions systems since 1976, appointed Director of Quality Control of Pontiac Motor Division. . . . **Cheryl A. Hutchins,** '72, named administrative assistant to the vice president of operations for Great Northern Paper Co. Ms. Hutchins joined the company in 1972 as a technologist in the research department. . . . **A. John Esserian,** '50, most recently from Baird Atomic, appointed Director of Industrial Relations at Analogic Corp. . . . **David P. Vanderscoff,** '66, previously Vice President and Actuary with the Manhattan Life Insurance Co., elected President of Northern National Life Insurance Co.

James E. Lydon, '50, formerly vice president of Corporate Relations at Boston Edison Co., named a senior vice president. . . . **George A. Wallace,** '53, appointed from group vice president for manufacturing to corporate vice president for administration of Olin Corp. . . . **Christian A. Gimre, Jr.,** '58, appointed manager of engineering and manufacturing services for Plastic Beverage Operations of the Plastic Products Division of Owens-Illinois, Inc. Mr. Gimre most recently served as manager of the company's Television Products Division man-

ufacturing plant. . . . **Randolph Pike,** '78, named Executive Vice President of Pike Industries. . . . **Stephen A. Landon,** S.M. '68, most recently director of planning process at PepsiCo., Inc., elected vice president — financial management analysis of Intercontinental Hotels Corp.

Deceased

Charles G. Tufts, '01; November 19, 1978; c/o R. D. Langdon, 714 S. Manilus Rd., Fayetteville, N.Y.
Albert A. Hayward, '06; August 30, 1978; 61 Hancock St., Auburndale, Mass.
Samuel L. Ware, '06; January 30, 1978; 620 Adams St., North Abington, Mass.
Warren J. Simonds, '11; October 8, 1978; 258 S. Main St., Orange, Mass.
Charles D. McCormack, '12; November 11, 1978; 1945 Maplewood St., Abington, Penn.
Russell A. Trufant, '14; February 4, 1976; 1272 Beacon St., Brookline, Mass.
Richard O. Bailey, '15; September 17, 1978; Old Lancaster Russell Rds., Berwyn, Penn.
David M. Hughes, '15; August 18, 1978; 7222 Senalda Rd., Los Angeles, Calif.
Max I. Woythaler, '15; October 4, 1978; St. Patricks Manor, 863 Central St., Framingham, Mass.
Frank W. Holmes, '16; September 18, 1978; 43 St. John St., Jamaica Plain, Mass.
Arthur K. Stewart, '16; August 30, 1978; c/o C.B.T. Co., Attn., J. B. Coleman, One Constitution Plaza, Hartford, Conn.
Richard T. Whitney, '17; November 7, 1978; Moon, Va.
Craig P. Hazelet, '18; June 21, 1978; Hazelet & Erdal Consult. Eng., 304 W. Liberty, Louisville, Ky.
Charles A. Chayne, '19; October 30, 1978; Box 1096, Pebble Beach, Calif.
Harry Stiller, '19; November 3, 1978; 200 Hoffman Ave., Apt. 305, Cranston, R.I.
Mrs. Benjamin E. Hopkins, '20; August 20, 1978; Crestview Club Apts., 5330 Harroun Rd., Sylvania, Ohio
Harold F. Smiddy, '20; September 9, 1978; 30 Sutton Pl., New York, N.Y.
Thomas B. Card, '21; December 23, 1977; 68 Beacon St., Boston, Mass.
Carl A. Ellis, '21; August 24, 1978; 282 Linden St., Waltham, Mass.
Rev. William F. Hastings, '21; November 1, 1978; 4736 W. Main St., R. 2, Fredonia, N.Y.
Robert R. Whitehouse, '21; June 28, 1976; Vickery Lane, Unity, Maine
Roger C. Bacon, '22; June 25, 1977; 7 Edison Ave., Medford, Mass.
Samuel H. Conrad, '22; August 14, 1978; Ford Ward Towers, Apt. 924, 2500 N. Van Dorn St., Alexandria, Va.
William G. Hodges, '22; May 17, 1978; 39 Ledgelawn Ave., Lexington, Mass.
Donald L. Moriarty, '23; August 5, 1978; 8 View Ave., Northampton, Mass.
George F. Nevers, '23; November 9, 1977; 755 Ellington Rd., South Windsor, Conn.
Brig. Gen. Harrison Shaler, '23; November 18, 1976
Dr. Kenneth M. McDonald, '24; February 20, 1976; 2928 Pine Haven Dr., Mountain Brook, Birmingham, Ala.
Jesse W. Green, '25; September 23, 1978; 689 Arden Rd., Pasadena, Calif.
Dr. Thomas J. Killian, '25; December 2, 1977; 1220 N.E. 17th Ave., Apt. 2B, Portland, Ore.
Leon Task, '26; November 19, 1978; 9400 Abbott Ave., Surfside, Fla.
Prof. S. Stuart Barker, '27; November 3, 1978; 1821 N.E. 25th Ave., Portland, Ore.
Fernando A. Canada, '27; January, 1978; Menorca 42 4 A, Madrid, Spain
Louis C. Scherer, '28; August 19, 1978; 108 Sagamore Rd., Apt. JA, Tuckahoe, N.Y.
Prof. Raymond D. Douglass, '31; October 15, 1978; 18 Oak Ave., Belmont, Mass.
Donald A. Rice, '32; October 24, 1978; 1536 Crofton Pkwy., Odenton, Md.
Stanley J. Szymczyk, '32; August 6, 1978; 22 Henshaw St., Chicopee Falls, Mass.
Harold F. Tonsing, '32; November 18, 1978; 140 Belmont St., Weymouth, Mass.
Mrs. Chester C. Dodge, '33; August 8, 1978; 24 Alban Rd., Waban, Mass.
Dr. Basil W. Parker, '33; August 15, 1978; c/o Herbert Fishbone, Box 1099, Easton, Penn.
Henry C. Miller, Jr., '34; November 10, 1978; 1301 Arboretum Dr., Chapel Hill, N.C.
Douglas F. Illian, '35; September 18, 1978; 704 S. Kenilworth, Oak Park, Ill.
William F. Newkirk, '35; August 11, 1978; 311 17th Ave., Baltimore, Md.
Richard O. Lane, '36; October 11, 1978; 878 White Lake Rd., Pleasant Lake, Mich.
Dr. Ely Mencher, '38; December 11, 1978; 170 Haviland Ln., White Plains, N.Y.
Robert J. Ely, '42; September 3, 1978; 28 North Rd., Niantic, Conn.
Prof. Pei M. Ku, '42; July 15, 1978; 279 Rockhill Dr., San Antonio, Tex.
Dr. Neil Campbell, '43; July 12, 1978; 10624 N. Kensington, Spokane, Wash.
Walter G. Sutton, '43; June 4, 1978; 152 Lombard St., Apt. 502, San Francisco, Calif.
Cyril M. Henderson, '45; October 14, 1978; P.O. Box 69, Inglewood, Ont., Canada
Joseph C. Nowell III, '48; November 2, 1978; 150 Ridgewood Dr., San Rafael, Calif.
William F. Arnold, '50; August 26, 1978; 3600 Montrose, Apt. 208, Houston, Tex.
William C. Reisener, Jr., '51; November 10, 1978; 349 N. Pottstown Pike, Exton, Penn.
Col. Harry N. Rising, '52; October 1, 1978; 3705 Bent Branch Rd., Falls Church, Va.
Dr. Stanley M. Bloom, '53; September 20, 1978; 89 Gordon Rd., Newton, Mass.
Alexander G. Grasberg, '56; May 23, 1978; 214 Chestnut St., Towanda, Penn.
Robert M. Langelier, '59; August 27, 1975; 6448 Johns Rd., Falls Church, Va.
Elpidoforos G. Ipiotis, '69; January, 1974; 10 Mourouzi, Athens, Greece
William C. Johnson, '70; October 17, 1978; 60 Garden St., Cambridge, Mass.
Gary O. Louie, '74; September, 1978; 1429 66th St., Brooklyn, N.Y.
James A. Cole, '76; October 9, 1978; R.F.D. 3, Nashua, N.H.



Dreaming the Possible Dream: U.R.O.P. Helps It Come True

Take an M.I.T. undergraduate and a willing faculty member, season liberally with ideas and enthusiasm, and put them together in a laboratory — and you've got the makings of a U.R.O.P. project. The Undergraduate Research Opportunities Program offers a rich variety of experiences for its participants, and it's unique — no other institute could offer such a program, said Margaret L. A. MacVicar, '65, Director of U.R.O.P., at the Alumni Officers' Conference last October.

U.R.O.P.'s mission is "to foster joint intellectual endeavors of mutual fascination by our faculty and our undergraduates," Professor MacVicar explained. Activities span all academic departments; each year about three-quarters of the students and half the faculty participate, and hundreds of off-campus professionals from industry, medicine, and government offer additional opportunities for faculty and students to collaborate. All undergraduates are urged to participate as early, as long, and as intensively as they wish.

Professor MacVicar told her Alumni Officers' Conference audience that U.R.O.P. "delights in the possible and aims to fulfill dreams"; but words are rather pale substitutes, she said: you need to see the gleam in the eyes of the student participants and the excitement of their faculty colleagues.

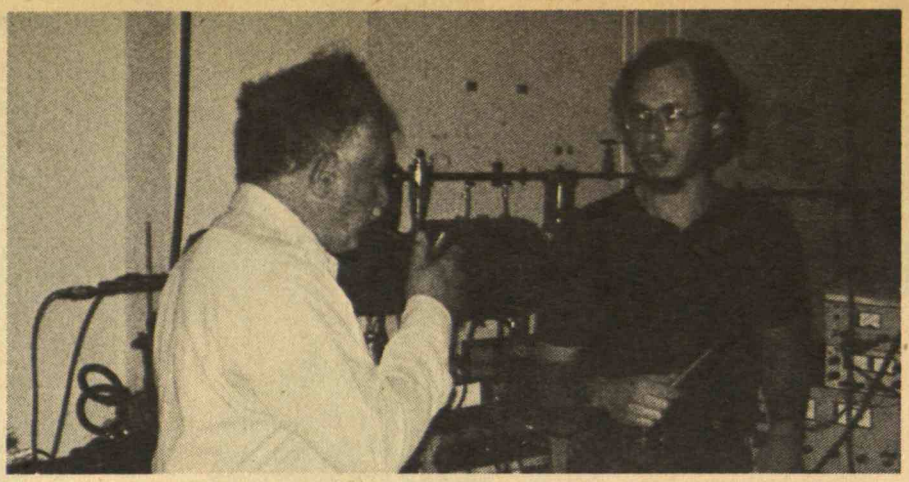
Dr. David Miller, chief of ophthalmology at Beth Israel Hospital, may not have expected more than a capable technician when an M.I.T. student joined his laboratory through the Undergraduate Research Opportunities Program. But after Warren J. Manning, '79 (photo opposite) spent a year doing research, Dr. Miller was impressed: Mr. Manning was astoundingly productive, and "his contribution was very important," Dr. Miller wrote to the U.R.O.P. office. (Photo: Gregory Smith, '30)

Research for the Real World

"This project was not just computer simulations; instead it aimed at building something that would in perhaps ten years be out in the real world working, producing energy for people," said Z Smith III, '81, of his solar collector research. He was interested in solar energy since high school, but it was much easier to be excited than to be knowledgeable — solar energy had caught the public's imagination, but there were no courses teaching it. So Mr. Smith was delighted to discover at M.I.T. the chance to work under the direction of Robert Frank, Visiting Scientist in the Department of Materials Science and Engineering, converting sunlight to electricity with photovoltaic solar cells.

There were two major pieces of the puzzle, explained Professor Roy Kaplow, '54, Mr. Smith's faculty advisor: planning a low-cost concentrator/collector system which could track the sun in two dimensions to achieve a high concentration level; and developing a photocell which would work well at high light intensity. Since there are so many aspects to a project like this — making the cell, designing a better one, tracking efficiently and economically, constructing the frame — Mr. Smith gained experience in many different fields and worked with almost everyone in the project.

What else did he gain? Income to help offset tuition costs, a lot of



One of the fruits of the Undergraduate Research Opportunities Program is the chance for students and faculty to work together — and learn from each other — in a way impossible in the classroom. Pictured above (left to right), Robert G. Benson, '81, Professor Walter M. Hollister, '53, and Nicholas R. Godbey, '79, who are designing a remotely powered helicopter model, at right, Professor Louis D. Smullin, S.M. '39, confers in his electronics laboratory with Barry Breen, '79. (Photo, right: Gregory Smith, '30)

knowledge, and practical experience in experimental technique. "I was able to do something theoretical that actually worked! And it has helped me to better decide what I want to do in terms of a career," he says.

Developments to "Excite an Entire Industry"

After Warren J. Manning, '79, worked on an off-campus research project for a year, the U.R.O.P. office received a letter from his off-campus supervisor, Dr. David Miller, Chief of Ophthalmology at Beth Israel Hospital, saying that Mr. Manning's "contribution in devising a device to measure the power of intraocular lenses while still in their sterile package was very important — the device has excited the entire industry."

Mr. Manning was working on a project to develop an alternative to refractive spectacles and contact lenses in the treatment of cataract patients. Surgery alters the curvature of the cornea so that the patient's eye has insufficient power to focus light images on the retina; a crystalline lens can be implanted to bring the eye close to normal. But the crystalline lenses arrive in sealed sterile packages, and approximately three per cent of the sealed packages contain lenses of the wrong power. Mr. Manning devised a method to measure the power of the lens without breaking the sterility of the package; if the method is marketed, he plans to have the proceeds go back to U.R.O.P. in the form of a scholarship.

Robert Mann, '50, Professor of Biomedical Engineering and Mr. Manning's faculty advisor, is particularly pleased with U.R.O.P.'s emphasis on goal-oriented problem-solving. He was initally attracted to engineering because it is practical — it uses theoretical analysis as a base, a means rather than an end in itself. He says M.I.T. represents a style of education which provides young people with a confident grasp of the underlying physical laws of nature and the ways of expressing them analytically and experimentally. A faculty member need not have the specific knowledge of a U.R.O.P. student's particular research in order to be of help; he or she can banter, question the style of inquiry, criticize outcomes, and offer suggestions for alternate routes of investigation.

Not for Undergraduates Only

U.R.O.P. is by no means a one-sided affair: the faculty benefits from the freshness and enthusiasm of the students. In off-campus research collaborations, students provide an outward link for M.I.T. with the community at large; contacts are established between departments and outside companies which can easily outlast the original U.R.O.P. projects.

U.R.O.P. is often listed in admissions folders as the reason for students' coming to M.I.T. "As an institute," says Professor MacVicar, "we are stronger in our commitment to undergraduates than we have probably been for a quarter of a century." —*S.K.*

03

Well, classmates, our old year has reached its end and we are fortunate to be well, active, and mostly in the 90 age group.

This bids well for our engineering careers. As we now look backward, we had many problems and successfully overcame them, even though we lacked the many present advances of each profession. Ours was a period of creativity, a time when Edison and other dormant geniuses were aroused to experiment and overcome their daily obstructions.

With the advent of a new year before us, let us relax daily, save our energy and live a plain, restful routine. Your secretary has found this system to be very successful. I have no alcohol in my blood stream, no rheumatism, consume no excess salt or meats, and use a cane in all upright moves to prevent any fall and bodily bone injury. This plan has been advised by the hospital director who marveled at my activity.

I am now a southerner, free from the inclement weather of New England and astonished at the mildness of Kentucky. No more ear caps and deerskin mitts.

I have received a most rewarding and happy letter from Mrs. Patricia Armstrong, wife of a 1964 alumnus, who has "so enjoyed my warmth and quiet insight." She is positive that the entire *Review* readership is grateful for my spirit that shines through each issue. Abundant thanks to her — **John J. A. Nolan**, Secretary, 417 Dorsey Way, Louisville, Ky. 40223

13

Note: the editors regret a typesetting error in our December/January issue. News reported about Walter Murray should have read **Walter Muther**. *We are indeed sorry for this inaccuracy. — S.K.*

The "poet of the Class of '13" has done it again. **Allen F. Brewer** sent us a copy of his poem with the following letter: "It was a great shock to both of us to read in the October Review of your loss of Phil. Coming so soon after the loss of Bill Brewster and **Heinie Glidden**, among others, it brought the uncertainties of life to us most forcefully. Phil and I had had a most enjoyable friendship ever since we entered Tech in 1909. Being in the first three letters of the alphabet we were in freshman classes together; later we were active in class committee work together. Thinking back, we are glad that you and he spent a bit of time with us several years ago. Now we have lost **Frank Achard**, as well. He was so active at the reunion that it is hard to believe he is gone. The last I remember of him was on the day we left Cambridge: He was in the washroom, singing in the shower.

"We are glad you are carrying on as Secretary, *protem*. You both have done remarkably well in keeping us advised of class news. Keep up the good work. On my part, I'll try to send you news from time to time.

I have developed a new activity recently. It dates back to the days in Boston when I wrote a couple of songs for the Tech Show in 1913; I've revived my desire to concentrate on words by writing verse. So far our local newspaper, the *Jensen Beach Mirror*, has very kindly used several of my contributions. The following is my latest, dealing with Vererans Day.

VETERANS DAY
America's wars spawned a loyal breed
Of patriots from the land;
From Molly Pitcher to Nathan Hale,
Her need was their command.
From father to son, from mother to daughter,
They came, or they were called;
When the chips were down they were on the line,
Americans never recoiled.
No color, nor race, nor sect, nor clan
Held back when the going got rough,
None felt themselves above their peers,
They proved to the world they were tough.
Bunker Hill, in the "times which tried men's souls"
Battle-tested the patriot's aim;
From there through the ages to Normandy,
There were veterans true to the name.
So we honor today in tribute
To the memory of those who died,
And the rest of us still living,
Americans march with pride.

There is not much other news. Three of my grandchildren have reminded me that time is passing on, by presenting us with four great-grandchildren, two girls and two boys. Healthwise we both are keeping well. The surgeon who did a bit of intestinal operating on me last May said two of the most welcome words in the dictionary when he discharged me several weeks later: "NO MALIGNANCY."

David Stern writes: "In common with so many of our classmates, I have been plagued with illness for almost two years, but I am able to maintain some activity." From **William G. (Jack) Horsch**: "So good of you to have taken over the jobs you are doing for the 1913 ("best") class." . . . And from **J. W. Brooks Ladd**: "I was sorry to hear about your husband's passing on. Way back in the turn of the century, we used to go to Kennebunkport for the summer and canoe the river. Those were the times and I still remember them."

We learned of the death of **Edgar W. Taft** from his brother-in-law, George W. Breck '26, and are indebted to him for this information. Edgar died August 2, 1978, at the age of 87 in Fort Lauderdale, Fl. After teaching physics at M.I.T. for two years, he was employed by the Winchester Repeating Arms Co., where he held several key positions, finally working up to the job as treasurer. Some of Edgar's lifelong interests were masonry, hunting, boating, and the U.S. Power Squadron. After completing several advanced courses in the latter, he did patrol duty in the New Haven, Conn., area during World War II. After retirement to Florida, he was active in the Coral Ridge Power Squadron. An owner of medium-sized boats, he performed many rescues of stalled boats and gave assistance to friends, neighbors and relatives in many different capacities.

Edgar is survived by four sons (all graduates of M.I.T.): Caleb S. Taft, '44, Dr. Edgar B. Taft, '38, John E. Taft, '47, and Barrett L. Taft, '40.

We also regret to report the death of **Edward T. Dobbyn**, 88, of Quincy, Mass., former chief naval architect for the Department of the Navy at Fore River Shipyard, on July 13, 1978, at Quincy City Hospital following a brief illness. Born in Charlestown, he attended Boston schools; Tufts College and M.I.T. He obtained a law degree from Suffolk University and passed the bar exam in 1927.

He had worked at Fore River Shipyard for 47 years before retiring 21 years ago. In World War I, he was "loaned" by the navy to Ford Motor Co. for the construction of Eagle boats. For his design and construction work involving 2,900 naval vessels in World War II, Mr. Dobbyn was given a special navy award of merit. Similar work on 1,100 vessels was done by Mr. Dobbyn during the Korean conflict. He is survived by his wife, Margaret M. (Breen) Dobbyn; two sons, Edward T. Dobbyn, Jr. of California and Robert E. Dobbyn of Braintree; a daughter, Barbara E. Egan of Wollaston; a brother, John F. Dobbyn of West Roxbury; ten grandchildren and three great-grandchildren.

Keep the notes coming so we'll have more news next month. — **Rosalind R. Capen**, Assistant Secretary, Granite Point Rd., Biddeford, Maine 04005

14

Philip S. Platt died on September 25, 1978, at the age of 88, in a nursing home in Mystic, Conn. He was born in Scranton, Penn.; after graduating from Yale, he was with us in our senior year and received a master's degree in life sciences, and he was awarded a doctorate in public health in 1927 by Yale. He served on the Hoover Committee for Relief in Belgium in 1916; as special assistant to the U.S. ambassador in Petrograd in 1917; as director of the New Haven, Conn., Health Center from 1920 to 1923 (when the center began the first program in the area in generalized health care and disease prevention); as assistant director in the research division of the American Child Health Association from 1924 to 1926; as director of the Palama Settlement, a public health and social welfare agency in Honolulu, from 1929 to 1942; and as director of the New York Association for the Blind from 1944 to 1957. He was the author of several books and journal articles in his field. After retiring in 1959 and making his home in Madison, Conn., Dr. Platt served on the boards of the National Society for the Prevention of Blindness, the Madison Visiting Nurse Association and the Scranton Memorial Library; he was president of the Connecticut Society for the Prevention of

Walter D. Binger, '16, celebrated his 90th birthday last year in the hunting field with the Fairfield County (Conn.) Hounds. (Freudy photo, originally appearing in The Chronicle of the Horse*)*

Blindness and of the Madison Historical Society; and he was a fellow of the American Public Health Association and a member of the First Congregational Church of Madison. Dr. Platt leaves his wife, Annetta Nicall Platt, a son, David N. Platt, of New York City, a daughter, Mrs. Kent Moore, of Mystic, and four grandchildren. — **Charles H. Chatfield**, Secretary, 177 Steele Rd., West Hartford, Conn. 06119

15

Here's hoping all you good classmates and your friends have enjoyed a bright and happy holiday season and are well in to a big year in 1979. Thank you all very much for the holiday cards and messages you sent me. It made me feel good to hear from you. My right hand fingers do not coordinate well, so I could not send my holiday cards. The annual trek of the "snow birds" flying to the winter shelters of Florida began early with **Jim Tobey**, **Wayne Bradley**, and possibly **Deiger Doane**.

Mary Plummer Rice was in London visiting her granddaughter. She has been home in Bronxville, N.Y., all winter busy with her work in veterans hospitals. . . . **Phil Alger** wrote that he has reached a "stable physical condition"; he can walk with a cane but not fast. (A remarkable recovery. Keep up your good work, Phil.) Phil has been active in local politics. The Schenectady paper, *The Knickerbocker News*, said "Philip Alger believes the 'strong mayor' referendum will be challenged this spring once people realize the changes they are in for when the mayor assumes executive powers now held by an appointed city manager.

"And, Alger is convinced that if no challenge materializes, Schenectady's first strong mayor, due for election to a four-year term next year, will be the last because services will suffer and corruption may spring up. Alger, 84, makes his predictions from a special vantage point. He led the Charter League of Schenectady in 1934 when voters replaced the old strong mayor system with a city council elected on a citywide basis with an appointed city manager."

How these old guys do get around! With a new car and a "new " leg after a fracture, **George Easter** has been chasing all around and will spend the winter in Florida with his married daughter. Nice going, George. Keep it up.

John Dalton keeps busy and in good shape in Providence. I enjoy phoning him.

For 1977-78 our class has the second highest Alumni Fund percentage participation, 65 per cent. Under Jim Donovan the Class of 1928 had 68 per cent. Our success was due to Joyce Bako's devoted and loyal efforts. Many thanks, Joyce. Write me something about yourself. All the best to you all. — **Azel Mack**, Secretary, 100 Memorial Dr., Cambridge, Mass. 02139

16

In answer to **Francis Stern**'s request, we have prepared and are in the process of distributing an up-to-date (November 24, 1978) class list. If you haven't received one and would like one, write us a newsy letter and you'll get one by return mail. We list 123 classmates, of these about six are "address unknowns." If you know the address of any of the "unknowns," send it to us. As a matter of fact, write me whenever you can on any subject. We aren't getting letters and we need them from you if we're going to continue to have an interesting column. Follow the example of **Arthur Shuey** who recently wrote: "I just came home from the voting poll, and I hope my men get elected for they are the best for the job. We have had an interesting summer even though my arthritic shoulder kept me from my usual Colorado trout fishing. We were fortunate enough to secure two visas to visit the People's Republic of China. We flew there in mid July and spent 15 days in Peking, Nanking, Shanghai, Harbin and two small communes. Chairman Mao did a good job of selling his people his brand of communism and they seem to like it. The people are well fed, well clothed, and everyone works. There is no evidence of scarcity and no queues as in Russia when one tries to buy limited supplies. Travel is directed by an English-speaking tour conductor who in turn is directed by China International Travel Service. Everything seems to be located on a hillside and one must climb countless steps to see the sights (pretty rugged for an 86-year-old visitor). The food is good; it is cut up in small pieces for your chopsticks. All water is boiled and you drink gallons of tea. Your hotel room has a huge thermos bottle full of boiled hot water for your tea. You carry your own instant coffee. If this resume of our China trip scares you off I am sorry, for it was a very interesting experience."

We were sorry to hear from **Theron Curtis** that his wife Hope has been suffering ill health for the past 12 months. . . . I also had nice birthday cards from Gladys and **John Fairfield** and from Virginia and **Joel Connolly**. Joel's was on a photo which he must have taken and was labelled: "The ocean meets the land in Macao, a bit of Old Portugal in the Far East." . . . We regret to report the passing of **J. Spotts McDowell**. A friend wrote: "He had a stroke on June 8 and died July 5, 1978." Also, we are sorry to note **Arthur K. Stewart** passed away on August 30, 1978.

In early December Sibyl and **Ralph Fletcher** enjoyed a delightful luncheon with Hildegarde and **Jap Carr** in Palm Beach, Fla. Jap has a Florida license plate (MIT '16) and he's quite proud of it. Ralph Fletcher has this same plate in New Hampshire, and **Dan Comiskey** has it in Massachusetts. I wonder whether others in the class have done likewise in other states.

Keep your letters coming and keep breathing. — **Ralph A. Fletcher**, Acting Secretary, P.O. Box 71, West Chelmsford, Mass. 01863

17

We were glad to hear that our architectural friend, **Jim Flaherty**, is still able to get about, at least for a walk around his home in Dedham, and especially to hear that he still occasionally wields his artist's paintbrush. We also have just received Jim's annual Christmas card: a lovely print of Jim's painting of his forebears' home in Bantry, Eire. . . . The engagement is announced of **Stan Lane** to Miss Mildred Moore of Andover, Mass. Mildred, an accomplished concert pianist, is director of music at Tremont Temple in Boston. A spring wedding is planned.

The Class of 1917 has donated $2,000 to fund a chair in Room 10-250. Also, these class members have each donated a chair: **Walter Beadle**, **Johnnie DeBell**, **Stan Lane**, and one in memory of **C.H.M. Roberts**, by his son, Thomas S. Roberts, Class of 1957.

We are sorry to report the death of **Dick Whitney**, on November 7, 1978. Dick passed away quietly in his sleep, after a long illness. His wife, Ruth, had died on January 14,1977.. They lived in their apartment in Moore, Va. Dick leaves two daughters, Ruth and Janet, a granddaughter and two great-grandchildren. . . . Doris and **Bill Hunter** had a good trip to Bermuda for Thanksgiving week. Besides enjoying good weather and nice scenery, we attended a Thanksgiving service at the Anglican Cathedral, given by the U.S. naval personnel stationed in Bermuda. Some of the ushers were dressed in Continental uniforms with powdered wigs and leather collars. A sermon was given by the Chief of the U.S. Navy chaplains and was attended by many Bermudians, as well as Americans.

Walt Medding had trouble with his eyes back in October and had to go to San Antonio to Brook General Hospital in Ft. Sam Houston to attend an eye specialist. . . . **Charles Venable** wrote that he was unable to attend our reunion in October and pleaded advancing years. Today Dr. Venable lives in Swarthmore, Pa. . . . **A.P. Sullivan** didn't think he could stand the long trip to Sturbridge from Pittsburgh, for the last reunion. He missed a lot of fun. . . . Vi Proctor, in responding to the invitation to the reunion, says it sounds great and she will certainly be with us in spirit. She is still keeping the home fires burning at Lincoln Park, N.J.

We received a call just after Thanksgiving that Dorothy Ross, the widow of **Ralph Ross**, had died. She had been in a nursing home near Baltimore and near her daughter, Mrs. Helen Staley. She is survived by four daughters and one son. . . . Jeannette Dunning is beaming over the arrival of her first great-granddaughter. — **William B. Hunter**, Secretary, 185 Main St., Farmington, Conn. 06032

18

Your secretary has been involved in the 19781979 alumni seminar series which meets once a month in Cambridge for dinner followed by a talk by an M.I.T. professor — and then a question-and-answer period. This year's program dealing with "Interactions between Science, Technology and Society" has been unusually interesting and educational. The December meeting was led by Professor Nazli Choucri of the M.I.T. Department of Political Science. I was surprised to learn that other Arab countries had taken in so many Egyptians as to create a labor shortage in Egypt, that the money sent back to Egypt by these workers cut the nation's budget deficit to manageable proportions, and, in addition, many other important changes resulted from the 1973 war with Israel. Here is an example of the exciting way M.I.T. is serving its alumni with continuing education.

Eleanor and **John Kilduff** are enjoying the sunny Florida weather until April at 4574 Great Lakes Drive South, Clearwater. Before leaving Rye Beach, he (John) set up the Kilduff Fellowship for a doctoral student in medical engineering at M.I.T. who wants to carry on a portion of his/her research at the Jackson Laboratories in Bar Harbor, Me. John had been instrumental in designing and supplying much of the special equipment for the Jackson Laboratories.

In late November, Hazel Fletcher stopped in Boston on her way to Florida where she will be until June. We had a most enjoyable get together with lunch and dinner including my better half, Selma, and Elizabeth Howe. Faithful **Jawn Abrams** writes that he will be moving to Glendale, Calif., in February.

Last month we reported the death of **Walter Wilson**. We have now received the review of his career: Walter C. Wilson was born in Lowell and made his home there all of his life. During World War I he served as a naval flying instructor and test pilot. Shortly after the war he returned to Lowell and became associated with the E.A. Wilson Co., and for over half a century served as its treasurer, a position he held at the time of his death. He was on the board of trustees of the Central Savings Bank of Lowell since 1928 (he was president of the bank from 1953 to 1970) and also was a member of the board of trustees of Lowell General Hospital, director and past president of the Lowell Boys' Club, a trustee of Lowell Cemetery, past president of the Yorick Club in Lowell and past director and member of the executive board of the Vesper Country Club in Tyngsboro. He leaves his wife Shirley, two sons, and a sister.

In a previous issue we recorded the passing of **Pete Harrall**, and now provide a review of his career: during World War I he served as a first lieutenant in the Corps of Engineers. Later, he worked for Western Union in New York for 23 years. In 1943 he moved to the Baltimore area to work for Bendix Aviation Corp., from which he retired in 1961. After his "retirement" he began a second career in education — he became business manager of Essex Community College and later held the same title at the Bryn Mawr School. Mr. Harrall was a former director of the Towson Library, a former board member of Valley Travel, and a member of the Society of Mayflower Descendents. He leaves his wife Frances, a son, a stepdaughter, and four grandchildren.

We note with sadness the deaths of **Fred Mills**, Keene, N.H., on July 22, 1978, and **Alfred B. Vought** of Melville, N.Y., on October 31, 1978. — **Max Seltzer**, Secretary, 60 Longwood Ave., Brookline, Mass. 02146; **Leonard L. Levine**, Assistant Secretary, 519 Washington St., Brookline, Mass. 02146

19

By the time you read these notes we should be well along on plans for our 60th Class Reunion. I hope that you will be able and willing to attend and that you will so advise your Secretary. It is pleasant to hear from classmates.

Ev Doten spent some time with his cousin, Mrs. Joseph G. Howland in Lexington, Mass., and kindly volunteered to help prepare for our reunion. . . . **George Bond** writes that he plans to attend the reunion. He has been busy with twin granddaughters' graduations and continued schooling; and he spent a good part of this past summer with nine grandchildren at his seashore cottage. . . . **Francis Weiskittel** also plans to attend the reunion; he writes that he is now past his 80th birthday, a Baltimore citizen for his entire life, with three children and one grandchild. He recently visited Disney World with his son, the eighth such visit.

George Michelson sends a clipping from the *Providence Journal* reporting the death of **Harry Stiller**, a Course I classmate who died early in November of last year. . . . Nancy Chayne Martin wrote to advise me of the death of **Charlie Chayne** on October 30, 1978. . . . We extend our sympathies to **Paul Sheeline** who developed a medically puzzling problem with his leg; after extended examination and tests, a surgical operation was performed — we hope he regains the use of his leg.

The class roster is thinning noticeably but as you'll see at our reunion there's a lot of life left yet. — **W.O. Langille**, Secretary, Box 144, Gladstone, N.J. 07934

20

A welcome letter comes from **Larry Weymouth** of 2892 State Rd., Clearwater, Fla. Larry writes that he retired 16 years ago after 35 years with Johns Manville. He has lived in Florida for more than a year after nearly a half century in Somerville, N.J. It is pleasing to know that Larry and his wife remain in good health. She is an avid flower gardener and Larry keeps in shape by playing golf two or three times a week, walking the course.

A Christmas card note from Florence and **Lee Thomas** says they will be at 207 Kingsport Club, Naples, Fla., for a couple of months after which they'll return to their home in Bryn Mawr.

I am indebted to Gaynor Langsdorf, '32, for information on the death of **Snug Etter** on October 8. Snug had made his home in Hillsborough, Calif., and had lived in that area for 36 years. After graduation he served as a mathematics instructor at M.I.T., then became an executive with the Air Reduction Co. He was a member of the prestigious Bohemian Club of San Francisco and was active in the Boys Club of San Mateo. He is survived by a daughter and two sons. Snug numbered many close friends in the Class and his loss will be deeply felt by us all.

The new year of 1979 reminds us that 1980 will be our 60th reunion year. That is truly something to contemplate; so hang on, fellows, and preserve your health and strength for the grand event a year from June. In any case, permit me to wish you all a happy and healthy new year. 'Twould be heartwarming indeed for your hardy perennial secretary if you would make a New Year's resolution to keep in touch. — **Harold Bugbee**, Secretary, 21 Everell Rd., Winchester, Mass. 01890

21

The "deceased" column in the November *Technology Review* listed the name of **Jack Van Horn Whipple**, who died on August 22, 1978. Somehow your secretary wasn't notified. Jack worked for a couple of firms after graduation and then returned to M.I.T. in 1929 as a graduate student in aeronautical engineering, leading to his S.M. degree in 1931. He remained on the staff at M.I.T. until 1934, then from 1934 to 1943 worked in research production methods, plant layout, product design, etc., for United States Gauge Co., National Bureau of Economic Research, and Sperry Gyroscope Co. and then as an independent consultant. In 1943 he became president of Whipple-Magin Corp. — industrial engineering — but resigned in 1945. From 1945 to 1954 he headed Whipple Co., later Whipple Associates, in industrial engineering, designing, and manufacturing mechanical and electrical instruments, tools, and precision parts for the Air Force, Navy, Republic Aviation, and others; the business was sold in 1954. From 1955 to 1966 he had contracts with the U.S. government as industrial advisor to the Philippine government and the government of Ceylon, then for the State Department, and finally with N.A.S.A. on the Saturn V project. He retired in 1966. Our sympathy is extended to his family.

This column reported last spring that **Frank Huggins** of Frogmore, S.C., was confined to home after hospitalization for a fracture and dislocated shoulder caused by a fall. In a pre-Christmas letter, his wife Ceil tells us Frank is bedridden but good-natured and jovial, has no pain and a good appetite. He gets daily exercise in his hospital bed which is located in a bay window looking out at a bird feeder and lush subtropical flora. He is grateful for the many letters he has received; Ceil says they "have done so much good." The letter ends, "I am thankful I'm able to give the care needed by Frank — my husband for 53 years and best friend for 60 years."

An Alumni Office information update returned by Commander **Glenn H. Easton** tells of his living in Satellite Beach, Fla., but spending his summers on China Lake near Waterville, Me. He adds, "Have traveled a great deal since Navy retirement. Also served as director of the 'Point Four' Operation Mission on Tripoli under the State Department. Later I taught engineering at Georgia Southwestern College, Americus, Ga. — a branch of Georgia Tech — until my final retirement for age. My wife Cornelia and I are both well."

An early November letter from **Wallace T. Adams** says, "I am always looking for news. Reading the *Cincinnati Enquirer* this morning, I noticed a column on the Bardes family but it was not about our Ollie Bardes (deceased). Except for admitting to getting older, things are about the same with us. No trips planned. The M.I.T. Fiesta in Mexico should be interesting but we've been to Oaxaca. We now have two great-grandchildren and two more due to arrive this winter."

Another November letter, this one from **Grant Miner**, says, "A bug, bigger than I am, bit me over three weeks ago and I've been in bed most of the time since. The same bug got Marianne but she's tougher than I am, so she's holding the fort. Have you had any word from the **Stewart Parsons** since they left on their hegira?" (Not a word — how about it, Jim?) A later letter from the Miners after Thanksgiving reported the bug had departed.

A letter to the editor of *Technology Review* written by **Dave Woodbury** reported that his father, Charles H. Woodbury, M.I.T. 1886, was being honored last fall in an exhibition of his marine paintings at the Vose Gallery in Boston. This is being covered in a separate article in *Technology Review*. Once graduated, Charles Woodbury never practiced engineering but became a marine painter. M.I.T. owns six of his large paintings of dolphins in the Gulf Stream. Dave and his wife plan to offer a painting to the National Gallery of Art at some future time. Dave was a student in the Electrical Engineering Department but preferred writing to engineering and has written many books on science for the layman, three scientific "whodunits," and numerous things for the *Reader's Digest*. Dave got degrees at both Harvard College and Stanford University before entering M.I.T. in the junior year. — **Sumner Hayward**, Secretary, 224 Richards Rd., Ridgewood, N.J. 07450; **Josiah D. Crosby**, Assistant Secretary, 3310 Sheffield Cir., Sarasota, Fla. 33580; **Samuel E. Lunden**, Assistant Secretary, Lunden and Johnson, 453 South Spring St., Los Angeles, Calif. 90013

22

We are featuring **Horace McCurdy** of Seattle because of his latest unusual award. Mac has received the annual "outstanding achievement in construction" award of The Moles, a national organization of men affiliated with construction of tunnels, subways, foundations and under-water projects. The award will be presented in New York in January. Projects in which McCurdy had a major responsibility include the Mercer Island floating bridge; 100 naval vessels; DEW Line installations and all of Alaska's naval air bases; the Prince Rupert, B.C., port; the City of Kitimat for its aluminum plant in British Columbia; four Canadian pulp mills; and bridges, highways, dams and other projects in several countries. We wish for Mac and Catherine all the pleasures they certainly deserve. We hope that our classmate, **William Mueser**, who received this award a few years ago, will represent us at the dinner.

The fall trip of Marian and **Roy Stone** has been included in their Christmas letter telling of their impressions of Istanbul, and the picturesque Palet 2 Seafood Restaurant on the Bosporus, the crowds in Athens, and the featured stop in Rhodes. They especially enjoyed revisiting Malta and Barcelona (remember Hannibal and his elephants). They toured Gibraltar and Casablanca, including shopping on a special trip to Marrakesh, and their boat stopped to visit Funchal, St. Thomas, and Port-au-Prince. They told of the thoroughness of passport checking in Havana, and the tours, shopping trips and availability of the Tropicana Night Club. They again report good health and a year full of varied and interesting activities.

Oscar Horovitz has included a notice from **William G. Rapp**, 16 North Chasworth Avenue, Larchmont, N.Y. 10538, who is working on a revised edition of his book "Construction of Structural Steel Building Frames." Bill has also sent slides and file cards with contact prints (over 200 original photos and copies of his paper presented at the I.A.B.S.E. Congress in Stockholm), to Rotch Library at M.I.T. . . . We are happy

The Roaring Sea on Canvas: David Woodbury's Tribute to His Father

Portrait of Charles H. Woodbury painted by John Singer Sargent, 1921, National Portrait Gallery, Washington, D. C.

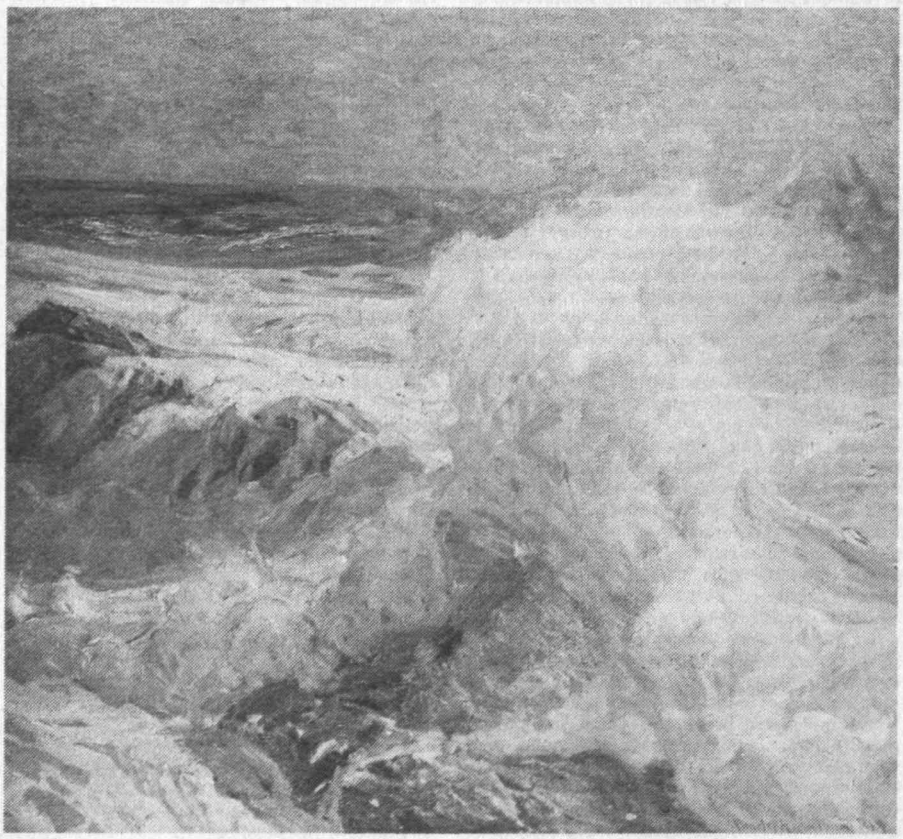
Even while he was studying mechanical engineering at M.I.T., Charles H. Woodbury, who graduated with the Class of 1886, found himself intrigued with the question of painting water in motion; whenever he could manage it, Mr. Woodbury was on a street car to Swampscott to watch the ocean — the stormier the better. As a student he had a studio on School Street where he established an art class and a reputation as a gifted and innovative painter and teacher.

There was only one significant exception to his success as a teacher. "Miss Oakes, I simply cannot teach you to paint. It's beyond me," he said. "But will you . . . er . . . mind . . . if I ask you to marry me."

All this and much more is recalled by Mr. Woodbury's son, David O. Woodbury, '21, in an essay for a catalog of Charles Woodbury's paintings currently on view in the Vose Galleries of Boston, Inc., 238 Newbury St. David Woodbury's earliest memories, he says, are of summers in Ogunquit, Maine, where his parents founded the summer art colony and where David and his wife now live.

Having completed his studies in electrical engineering, David Woodbury, like his father, turned away from engineering — in this case to writing, where he won distinction as an editor and writer on technology.

Several of Charles Woodbury's paintings are included in M.I.T.'s art collections — including two of porpoises in the Gulf Stream which for many years enriched the second floor balcony of the Building 7 lobby. Sixty of them are in the current exhibition and sale, confirming David Woodbury's claim for his father: he "painted every conceivable phase, action, and behavior of the sea. . . . He always made the water in his pictures move; more, he could make it roar, too."



The Breaker.

to see that the Allen Swallow Richards Professorship has received major additions from gifts and challenge funds through the efforts of **Marjorie Pierce**, chairwoman. The Alumni Fund has also been generously aided by gifts from the Class of 1922 and earned challenge additions in dollars. Your secretary hopes to call on class members in Florida during February and March to obtain a consensus on future meetings. He reports that residents of Buffalo are singing: "We Wonder Where the Winter Is" because there had been no snow up to December 10, and the temperature was 45 degrees — continuing good golf weather. The same good weather, good times and good health to you all . . . . **Whitworth Ferguson**, Secretary, 333 Ellicott St., Buffalo, N.Y. 14203; **Oscar Horowitz**, Assistant Secretary, 3001 South Course Dr., Pompano Beach, Fl. 33060

23

Theodore M. Edison has an article in the July 1978 issue of the *Professional Engineer* about his father's approach to invention, and his breadth of interest and accomplishment. . . . **Tom Rounds** was in Cambridge on business in early November and spent an evening at the Fraziers. . . . **Julius Stratton** and your secretary-treasurer attended the November 27 meeting of the Alumni Council at the Institute.

Our current (1973) class constitution provides for an "advisory committee" consisting of all past officers. A little curiosity and a search of the *Great History* turned up the following names: **Elliott A. Adams**, **Horatio L. Bond**, **Herbert L. Hayden**, **Forrest F. Lange**, **Charles M. Mapes**, **James A. Pennypacker**, **Albert S. Redway**, **Howard F. Russell**, **Edwin H. Schmitz**, **Roscoe H. Smith** and **Lyman L. Tremaine**. Readers are invited to report any omissions discovered. In strict interpretation of the constitution, and to minimize the volume of advice, only elected officers have been included. Eight former officers have died.

From Worcester, Mass., papers we learn that **Myles Morgan** died at his home there last October 3. Myles spent his entire professional career with the Morgan Construction Co., starting as a draftsman, becoming chairman of the board in 1963, and being appointed honorary chairman of the board in 1975. In 1972 he was awarded the Bessemer Gold Medal of the British Iron and Steel Institute for his work in the development of rod and strip mills; he was one of only six Americans to receive this medal, the industry's highest award. He obtained over 60 patents in the field. During World War II he spent two years with the Office of Scientific Research and Development. He was a director or trustee of several banks and businesses, and was active in promoting Boys Clubs. He was a member of the M.I.T. Future Development Committee and a president of the Worcester County M.I.T. Alumni Association. — **Richard H. Frazier**, Secretary-Treasurer, 7 Summit Ave., Winchester, Mass. 01890, Telephone (617) 729-3114

24

We were happy to receive a letter from **Ed Hanley** in Pittsburgh, Penn., responding to our plea for Notes material. A news release dated November 7, 1978, states that Ed was presented a specially made classic Wilkinson Sword and a scroll reading, "The directors of Allegheny Ludlum Industries, Inc., herewith take note of the retirement of their friend and fellow director, Edward J. Hanley; commend him for more than four decades of outstanding service to this corporation; and express their sincere regret at the termination of his long association with the board."

Ed joined Allegheny Ludlum Steel in 1936 following ten years with General Electric Co. He served the corporation successively as secretary, treasurer and vice president before being elected to the board of directors in 1947. He became president and chief executive officer in 1951; assumed the additional responsibilities of chairman of the board in 1962; and served in that

capacity until 1972, when he became chairman of the finance committee of the board.

"Ed Hanley has been not only one of the nation's best known and most highly respected business leaders for a quarter of a century, but he has also devoted the time, the talent and the energy to volunteer leadership in his church, outstanding universities, other education, health and welfare activities. A founder and early leader of the Allegheny County United Fund (now United Way), Ed Hanley and his wife, Dolly, have been vital leaders in the civic, cultural and social life in Pittsburgh."

John O. Holden's wife, Grace, has informed your secretary that John passed away September 29, 1978, at the South Shore Hospital in Weymouth, Mass. He was weakened by anemia, complicated by glaucoma and cataracts. "Joe" gained his degree in business engineering and administration and spent his career with Barbour Welting Co. in Brockton, Mass. He received his commission in the U.S. Army Engineers Reserve Corps. At the Institute he was active in several organizations, including the American Military Engineers. He was treasurer of Thayer Academy for years and active in several civic organizations. A double bond existed with the Institute, as Grace's father, Fred Tucker, was Class of 1900.

A card to the Alumni Association reports the death of **Theodore W. Kenyon** on October 15, 1978, in Ole Lyme, Conn. Ted's degree was in electrical engineering. He listed himself as an inventor, development engineer, consulting engineer, and owner of his instrument company in 1949 when he lived in Huntington (Long Island), N.Y. At the Institute he was a member of several organizations and performed on the swimming and gym teams.

Frank Shaw, Class President, and **Ed Moll**, 55th Reunion Chairman, continue to work on the 55th agenda as ideas come in from classmates. On June 6, revelers will be arriving at McCormick Hall or the Sonesta Hotel for dinner. The 7th is optional Boston activity and Pops. Friday, June 8, is Technology Day and a safari to Exeter Inn, (Exeter, N.H.) for a clambake. Saturday, the 9th, is Enigma Day, class banquet and election of officers. What's your question? — **Russell W. Ambach**, Secretary, 216 St. Paul St., Brookline, Mass. 02146; **Herbert R. Stewart**, Co-Secretary, 8 Pilgrim Rd., Waban, Mass. 02168

Harold E. Edgerton, '27 (left) at Technion Institute in Haifa, Israel, with Joe Zeitlen, '39 (right), professor of soil engineering at Technion and president of the M.I.T. Club of Haifa, and David Maestro (center), head of Technion's technical photography department.

Professor Edgerton's visit to Haifa was in connection with a comprehensive underwater survey of the coast in search of ancient shipwrecks of historical value.

25

There is little to report for this issue of the *Review*. I have talked several times recently with **Will Mahoney** who is a regular attendee at our Chatham Retired Mens Club. He sends his regards to all and is holding up very well. . . . A Christmas card from **Fred Greer** indicates that he is enjoying the winter in Naples, Fla. A friend at the headquarters of the M.I.T. Quarter Century Club tells me that **George McDaniel** had been interested in one of the charter tours to South America. If George travels in that direction I hope he will let us know about it.

This seems a good time to ask if any of you can tell us the whereabouts of several class members for whom we have no good addresses. There are many who were last known to be on the mainland of China and that we can't reach them is understandable. Let me mention a few others. **Wendell Burbank**, Course I, was last known to be at 27 West Mountain St., Worcester, Mass. He was a Theta Xi. **Wade Johnson**, Course II, attended the 45th Reunion in 1970. The most recent addresses indicated that he wintered in Fort Myers, Fla., and summered in Stow, Mass. **Stanley Freeman**, Course II, hasn't been heard from for some time but the last address was 1920 South Courtland Ave, Park Ridge, Ill. **Scott Emerson**, Course X and Psi Delta, hasn't been heard from for years. I recall that several years ago someone mentioned that he heard occasionally from **Frank Broadhurst**, Course I. We can't reach him at 286 St. Kilder Road, Melbourne, Australia. If anyone has information regarding these classmates please let me know.

Finally I am sorry to report the passing of **Clarence Barron** in Beaumont, Texas on September 12, 1978. — **F. Leroy (Doc) Foster**, Secretary, 35 Woodland Way, P.O. Box 331, North Chatham, Mass. 02650

26

Oh what a beautiful morning!
Oh what a beautiful day!

After a wild night of high winds, snow and sleet the sun shines on a white Pigeon Cove from a beautiful sky with just a few decorative clouds. After the February '78 Blizzard (capital "B") we are apprehensive when things start to churn up outside, but this was a nice storm preceded by two days of sorely needed rain. It is just two weeks before Christmas as we write but it will be February when you read.

Over the years one of our most faithful correspondents has been **Whitney Ashbridge** — always a traveller and for many years a big game hunter. He still keeps in touch: "We took a little trip through eastern Canada, including the Gaspe peninsula, somewhat more built up than when we were there about 25 years ago, but still beautiful and lots of seabirds. Expect to head west later in the year."

Our least active correspondent has been written up most in the Notes because he has been in the news so often — **Stark Draper**. This year (1978) he was awarded a Bronze Beaver by the Alumni Association; the award reads: "Doc's spirit of achievement and his unparalleled service to M.I.T. is a source of inspiration to generations of students, faculty, and alumni as teacher, research leader, and space pioneer. Through a career of more than half a century Doc's intellectual curiosity and courageous leadership exemplify the spirit of M.I.T." We know all this, but it is nice to tie it to the top Alumni Award. In late October, Stark delivered the 17th Lester D. Gardner Lecture at M.I.T. on the history of aeronautics. The lecture was established by a bequest by the late Major Gardner, '98, publisher for many years of the magazine *Aviation and Aeronautical Engineering*.

George Breck sent in some news from Ft. Lauderdale recently: "Ruth and I had a nice visit from **George A. Booth**, '26, in early '78. He and wife 'Peg' had been touring Florida. We were close at M.I.T., but I hadn't seen him for maybe 40 years. Like myself he had some heart problems ten years ago. He has pulled out of it well — does exercises, push-ups, etc., keeps weight down. Looked fine." George also mentioned that he and his wife have been following the Nathan Pritikin diet which emphasizes *exercise* and in parentheses "not sitting on the fanny in a sailboat!" We will have to introduce George to the trapeze that is used on many modern racing sailboats to enable the crew to keep the boat right side up. Admittedly there is no trapeze on *Beaver II* but let's say that sailing is a wonderful *substitute* for exercise.

A letter from **Eliot Bidewell** at the time of Allen Clarke's death mentioned that Eliot and Madeline had celebrated their 50th wedding anniversary with a month tour of the southwest and the national parks. Eliot ended his letter, "Hope we make the 55th." I think he meant reunion, but there seem to be a lot of 50th wedding anniversaries coming up between these two reunions, which means two 55ths ahead for many.

We haven't heard from **Charlie McHugh** for a long time so this message from Orlando is most welcome: "Life as a whole is pretty good. Last spring I took a trip around Asia visiting Hawaii,

Japan, Taiwan, Hongkong, Bangkok, Singapore, Jakarta, Australia, New Zealand, and several islands. I was impressed with the progress."....

It's nearly time for Simon, our new Sheltie, and me to take our evening stroll; but before signing off, we must report the deaths of several classmates. As I have mentioned before, this is the unpleasant part of being class secretary — with the result that I have sometimes procrastinated. However, in this instance many of the deaths have not been reported until recently. I will report as a group with the date of death. **Raymond A. Freeman**, 2-10-78, **W. L. Freeman**, 10-5-76, **Joseph B. Merrick**, 9-26-77, **James S. Moon**, 10-31-78, **W. Winsor Peterson**, 12-20-73, **William M. Walworth**, 4-16-78, **Robert M. Glidden**, date unknown but apparently some years ago. Ray Freeman and his wife Dorothy attended our 50th reunion and Mrs. Freeman wrote shortly after Ray's death telling of her pleasure that she and Ray had been able to attend the 50th and that it will always remain one of many memorable occasions. Simon is getting impatient for his walk so we must say cherio until April. — **George Warren Smith**, Secretary, P.O. Box 506, Pigeon Cove, Mass. 01966

28

Florence and I are about to depart for a one month stay in England to be on hand for the arrival of Jope grandchild number seven; for this reason no holiday cards are being sent and our usual year-end greetings are postponed. We mention this here because so many of you have written kind and thoughtful notes which we had expected to answer in our holiday mail. May we take this opportunity to send all of you our belated greetings!

The employees' news periodical of Consolidated Edison Co. of New York, Inc., for July/August, 1978, carried a two-page story on **Bill**

Bill Murphy, '28

Murphy under the title "This Bill's No 'Ordinary Guy.'" The item describes Bill as one of the company's most competent and respected engineers. Following graduation in 1928, Bill went to work for New York Edison (which became part of Consolidated Edison); his career with the company spanned both engineering and economics and Bill became a recognized expert on setting rates. Although formally a retired assistant vice president, Bill still works for the company as a consultant. A testimonial dinner marked the completion of his 50th year as an employee. Few of us can claim such a record. To you, Bill, our congratulations!

Elsie and **Myron Helme** were forced to cancel their plans to attend the reunion last June because of medical problems; later in the summer they were enough improved to undertake an Alaskan cruise. On the overland trip from New York to Vancouver, Elsie had an unusual experience: because of a poor knee condition she was unable to climb a steep boarding ramp for replaning at Winnepeg — so the ground crew put her aboard with a fork lift! The Helmes were home in time to enjoy the fall foliage and to prepare for a winter stay in Florida.

Libby and **Stew Newland** were also unable to be at the reunion but wrote to **Jim Donovan** expressing appreciation for the 50 Year Class Book. Their son, Stewart Jr., has a dental practice in Boston.... By the time these notes appear in print Helen and **Roland Earle** will be enjoying a dream vacation: they will be on a cruise that takes them throughout the Far East including China. They like the idea of a traveling hotel — they don't have to pack and unpack endlessly.... **Art Josephs** has undertaken the Area Chairmanship of the M.I.T. Leadership Campaign for the northern Minnesota area. Art's other activities in the interest of the Institute have included Educational Advisor and President of the M.I.T. Club of Duluth.... **Morey Klegerman**, serving as Special Gifts Chairman for the Class of 1928 in the New York area, recently turned in a report of 97 per cent participation for his group. This nearly perfect score was the highest for that category of donors and Morey certainly deserves our hearty congratulations.

Chemical and Engineering News, a publication of the American Chemical Society, listed in its June 19, 1978, issue the names of Society members being honored for fifty years of membership. Appearing therein are four of our classmates: **James M. Farnum**, **J. K. Roberts**, **Gilbert C. Toone** and **F.P. Walden**. This just confirms what we have already known — loyalty is a strong '28 characteristic.

We regret to report that **Louis C. Scherer** died on August 19, 1978. Lou graduated from West Point in 1925, then entered M.I.T. and graduated in electrical engineering. During World War II he served in the U.S. Army Corps of Engineers as a colonel. Prior to retirement he served with the U.S. Central Intelligence Agency. Besides his wife, Eleanor, he leaves a son, a daughter, and seven grandchildren. To his family we extend our heartfelt sympathy. — **Walter J. Smith**, Secretary, 37 Dix Street, Winchester, Mass. 01890

29

Eric A. Bianchi, who moved to Florida two years ago (500 Ocean Dr., Apt. 5DW, Juno Beach, Fla. 33408) has sent a note, "We now have been through two Florida summers and I find them delightful — crowds are gone, the golf course uncluttered, and the ocean and pool are always available and refreshing. Kay has a different opinion and has declared she is going north next summer. We did spend ten days in the mountains of North Carolina last August, and it was delightful to sleep under two blankets. Kind regards to all."... **Amasa G. Smith** writes, "I would like to thank you for the birthday geetings you have sent me from the Class of 1929 and express appreciation for a find job you are doing as secretary. I always enjoy reading the class notes in *Technology Review* which keeps us informed about activities and well beings of our classmates. **Larry Luey** plays golf with our group we call 'Dog Fight!' He is fine and enjoys good health. I manage to stay busy as ever with the Board of Community Chest, (United Appeal) as well as several other agencies (Y.M.C.A., Boy Scouts, Red Cross, etc.). We are looking forward to our 50th Reunion next June. Best regards and wishes to all."

Myron B. Helme writes, "You have not heard from me before, because, being Course VI-A, I am supposed to be a member of Class of 1928, although I received my degree in 1929. I was glad to read about **Sy Baum** in the November issue of the *Review*. My wife Elsie and I spend our winters (January through April) in Florida and we may be interested in attending the 50th Reunion of the Class of 1929."

Thomas W. McCue is still actively self-employed. He purchases and sells steel and other metals and does research in products technology. He sends best wishes to all.... **Henry S. Muller** has retired and is living leisurely with his wife Natalie on their Belmont, Ohio, acres. "I am visiting doctors and attending hospitals for body repairs. Many thanks for the birthday card, which reminds me that I am one year older since the last one."... **Gus Stein** has been living in Boca Raton, Fla., since retirement. Though his wife Ruth passed away some years ago, he enjoys a large family of two children, seven grandchildren and one great-granddaughter.

I received a note from **J. Henry L. Giles**, who has retired from his professional career as a sanitary and municipal engineer and is running a retirement home for the elderly. He writes: "Here is my first letter to the class of 1929 since — who knows when? My occupation in engineering (state and city) and family responsibilities have kept me occupied until now so that M.I.T. seemed far in the background. Now that our 50th Reunion is coming up next June, I thought I might send some information." Henry has been a sanitary engineer for over 43 years, dealing with solid waste management and waste water control. His areas of operations and activities have been Hartford, Conn.; Pasadena, Calif.; and Brookline, Mass. He has produced over 100 papers and reports on design, operation and maintenance for waste water treatment plants, swimming pools and refuse collection and disposal. He belongs to a number of professional societies, including American Public Works Association and the American Academy of Environmental Engineers. Since retirement Henry has been running a guest house for a few elderly senior citizens, ranging in ages from 74 to 94, himself being a young 71. He is planning to attend our 50th Reunion next June with an "if" — how to leave his responsibility for so many days.

Joaquin J. Llanso has retired as president of Knight Industries, Inc., but continues to be semi-active with the company, assisting with the promotion of its international business. "For the present, I shall continue to live in Tulsa since I go to the office a few hours most everyday. Recently, my wife Dorothy and I took a three week vacation trip to Europe, visiting England and Scotland (where we never had been) as well as Madrid and Palma de Mallorca in Spain (where I have family connections). We also visited my sister and her husband, whom we had not seen for 27 years, in Tangiers. On the way back we stopped over for a few days in Lisbon. God willing, we will be attending our 50th Reunion next June."

Frederic L. Bray sends a note, "First, let me thank you for the annual birhtday cards I have been getting, and I am not going to question the motivation. I would be happy to settle for a rose-covered (mortgage-free) shack by the side of a warm sea, but my wife Irene has become attached to the amenities of our wooded acre in a suburban community in Newark, Del. We are both healthy and support a dog, a cat and a mother-in-law equally healthy. We play a good game of tennis and keep active."... **Violet O. Parker** is proud to imply that perhaps she is the oldest member of our class, being 86 years old. As such, she has given up most of her class activites and reunions. "I took no part in my husband's Harvard reunion (Class of 1913), and I only recognized the name of one friend who attended. I wish the best to all, being grateful for my connection with M.I.T."

Hunter Rouse, the "Old Faithful" who never forgets me, sends a post card: "Greetings from Brazil, where I am giving 20 lectures and gathering gems. Last month I spent two days at M.I.T. with the civil engineering visiting committee. The place sure isn't the same any more. See you at our 50th Reunion in six or seven months."... **Rolf A. Zurwelle** writes, "I have enjoyed reading the class notes in the *Review*. Recently, we sold our beautiful farm in Churchill, Md., and moved to Walhalla, S.C. to a two-and-one-half-acre farm. Last winter we had over a foot of snow for more than six weeks and work under such conditions was too much. Our new place has a small spring-fed lake, and our home soon will be under construction. I will continue with the Zurwell Co., doing general engineering and industrial product design. I hope to get my South Carolina professional engineering license so as to be able to serve my clients in Illinois and Virginia. We hope to attend our 50th Reunion, but this relocation may not make it possible."

A note from the widow of **John S. Saloma** announces the death of her husband on October 15th, 1978, after open heart surgery.... Joseph S. Yates '27, sends a note informing that his brother **Edward A. Yates** passed away on November 1, 1976. He was a retired professional in the engineering department at the University of Michigan.... The widow of another classmate, **Ralph B. Atkinson**, sends this note: "Ralph died

on June 11, 1975, on his way home from a trip to San Francisco. The cause of his death is not completely clear, but it appears that he either fell asleep or had a fainting spell and his car left the road and overturned. He was alone in the car."

I received a note from the Alumni Office that **Alfred N. Lawrence** passed away on June 8, 1978. No details available at this time. . . . Another member of our class, **Carl W. Harris**, entered the "Eternal Life" on April 30, 1978. He was chief engineer of the Public Utilities Commission for the District of Columbia for many years. He joined the Corps of Engineers and saw action in North Africa and Italy, earning the rank of a Lieutenant Colonel. Upon his retirement, he moved to Longboat Key, Fla. He was a member of many professional societies, including the American Society of Military Engineers, the American Society of Mining Engineers, and the Longboat Key Bike and Hike Club.

Our 50th Reunion attendance is getting bigger and brighter. Mark your calendar: June 4 to June 7, 1979. This will be your chance to attend a reunion which tops them all. Don't leave any room for regrets later. — **Karnig S. Dinjian**, Secretary, 6000 N. Ocean Blvd. Apt. 14-E, Ft. Lauderdale, Fla. 33308 (305) 924-0425

30

At a recent dinner meeting of the Fairfield County, Conn., M.I.T. Club, your secretary chatted with **Tony Savina**, who organized the meeting, and **Les Steffens**, who gave me a run-down on his recent activities. As previously reported in the Notes, Les retired from Mobil Oil Corp. in 1973. Since that time he has been active in sailing. Under the auspices of Senior Sports International Corp., a non-profit organization devoted to promoting sports competition among seniors, Les organized the Sunfish Senior Olympics, now in existence for more than three years. The group holds an annual racing regatta in Darien each September. About a year ago they went international and accepted an invitation from the Club Puerto Azul near Caracas, Venezuela, to compete in a regatta held last January. The Venezualan Club organized a program with three days of tune-up racing followed by three days of competition. The attendance was a bit lopsided with only 12 U.S. skippers participating against 41 Venezualan entrants. However, Les managed to come up with first place in the 65-plus group and a fourth place in the 60-plus group. He also received an award Por Espiritu Deportivo for being the oldest skipper to complete the five races that were sailed in each event.

Another marine activity in which Les is involved is reproducing a whale boat of the type that sailed Long Island Sound two hundred years ago. A second whale boat of the same type is being built in Huntington, L.I. During the Revolutionary period such boats were used by Long Island Tories to cross the Sound and raid the Connecticut patriots. The Huntington and Darien whale boats will have a series of races, to determine whether New Yorkers or New Englanders build better whale boats.

After a stint as dean of the New Jersey State Medical School, **Morris Shaffer** has returned to Louisiana State University Medical Center as coordinator for the Office of Research. He is "having a ball" in his current assignment which involves acting as a sort of ombudsman to the younger faculty members who now have someone to whom they can turn for advice about potential sources of funding and a friendly but candid evaluation of the merit of their proposals.

George Lawson has retired and he and Gerrie are living Stuart, Fla. He lists his hobbies as travel, golf and fishing, and says that he has recently seen **Dick Chindblom** who is semi-retired. . . . **Elias Klein** retired about ten years ago from his job as assistant general manager (technical) of the South African Iron and Steel Corp. in Pretoria. He continued doing consulting work for various firms until December, 1976, but has now fully retired. . . . We have at hand a note from Ellen **Lindell** bringing the sad news that **Lauri** is having some health problems. Because of several strokes and surgery he is more or less bedridden. However, he would enjoy seeing any architectural classmates who happen to be in Lexington, Mass., with spare time available.

In preparing this month's Notes I was reminded that I have previously failed to report an M.I.T. related event in my own family. Last March my son Bob married Nina Rosoff. At the time they met, Nina was a research associate and instructor at M.I.T.'s Sloan School. She has a twin brother Eric and an older brother Peter, both with degrees from Sloan School. While Bob strayed a bit to collect an electrical engineering degree from Lehigh in 1966, he redeemed himself with an S.M. in management from Sloan School in 1973. He is presently manager of New Product Development at American Can Co. in Greenwich, and he and Nina are living in Darien. . . . **Gordon K. Lister**, Secretary, 530 Fifth Ave., New York, N.Y. 10036

31

It was a great shock to learn of **Raymond Douglass**'s death last October. Most of us will recall Prof. Douglas as a math teacher when we were at the Institute, not realizing that he received his Ph.D. at M.I.T. in our class. Our sincere sympathy to his wife Ollave and three daughters. . . . **Dick Ashenden** writes: "We took a two-week trip to Hawaii in the spring, visiting Oahu, Hawaii and Mauii. This summer we lived on our *Bermuda-30* for five weeks, visiting Cape Cod, Manchester-by-the-Sea, Newport, Block Island, Cuttyhunk and Padanarum. From Octoher 9-19, we will be sailing with John, '32, and Peg Lyon in their *Chesapeake-32*. We are looking forward to the mini-reunion of our class in Bermuda in April, 1979."

News from **Fred Elser** by ham radio tells of **Roger Wilson**'s marriage. Her name is Betty and they were married last year. Fred is studying hard for his Ph.D. in Honolulu. Fred also says that all is reportedly well with **Cliff Harvey**.

We hope to see you at the mini-reunion in Bermuda, Friday, April 26 — Tuesday, May 1 (four nights and five days). — **Edwin S. Worden**, Secretary, P.O. Box 1241, Mount Dora, Fla. 32757; Assistant Secretaries: **Ben Steverman,** 3 Pawtucket Rd., Plymouth, Mass. 02360 and **John R. Swanton**, 27 George St., Newton, Mass. 02158

32

Robert B. Thompson has written a letter which could be called a class secretary's delight. It is full of information concerning himself and other classmates. Here is the complete letter:

"As for myself, I am now fully retired. I spent some 33 years with The Dorr Co. — now Dorr-Oliver, Inc., with headquarters in Connecticut — and left them in 1970 to operate as an independent consultant for a few years. We sold our home in Wilton, Conn., in 1975 and, just to be different, moved north instead of south to Boothbay Harbor, Me., where we are now enjoying retirement with plenty of time available to pursue our hobbies. Our two daughters are now married and living in Connecticut, all involved with raising the next generation — four grandchildren.

"One of our neighbors whom we saw occasionally in Weston, Conn., is our classmate **Fred Green**. Fred is retired from his position with Nash Engineering, although I believe he is still on the board of directors. He has problems with arthritis but is his usual friendly and cheerful self.

"Here in Maine, I ran into **Bob Follansbee**, who makes his home in South Portland. He is retired from his job with Portland Pipe Line Co. where I believe he was vice president. Bob seemed hale and hearty.

"To Course I graduates with fond memories of Camp Technology: on a trip 'down east' this fall we discovered that the area is little changed from the summer of 1930 when we studied surveying there. Machias and East Machias are about the same; if anything they are smaller towns than the ones we knew on Saturday nights. Gardiner Lake appears to have been developed slightly by the addition of a few summer cottages but in the main is still the same unspoiled wilderness which we knew and enjoyed.

"I extend a cordial invitation to any of our classmates who join the throngs visiting Maine to give us a call and pay a visit. The sun goes over the yardarm quite early in the day!"

Dr. Carroll L. Wilson, Mitsoi Professor in Problems of Contemporary Technology, Emeritus, at M.I.T. makes the news again: he is the head of the World Coal Study, an international workshop of 35 people in key industrial, government, and academic positions from 15 countries who have begun a global study of the production, use and trade of coal. "We are in a race with time," Professor Wilson says, "a race made more difficult because claims still abound that there is no energy problem that needs attention now."

We received the sad news that **Stanley J. Szymczyk**, 70, of 22 Henshaw St., Chicopee, Mass., died in August, 1978. He leaves his widow Bernice and daughter Susan Musiak. Our class sends our heart-felt condolences to the bereaved.

Barbara and **John Flatley** came to the Alumni Officers' Conference at M.I.T. in October, and **Don Whinston**, **George Kerisher** and I with our spouses joined them there. We held our own class meeting to discuss plans for a mid-period reunion. The time selected was the fall of 1979, the place either Mexico or Williamsburg, Va. John will contact the class with full details. Keep writing. — **Melvin Castleman**, Secretary, 163 Beach Bluff Ave., Swampscott, Mass. 01907

33

Burt Webster has responded to one of my easy reply messages. I have seen little of Burt for a long time, and it is entirely my own fault, as I have had to stop attending the monthly meetings of the Alumni Council at the Faculty Club. Burt used to be a fixture at the left end of the bar (holding it up with one arm) and he has always been a work horse when it comes to reunions, committees and such. This year no Burt: "I missed the preparations for the 45th, and a visit to Massachusetts General Hospital was substituted for my attendance at Chatham. The new Pacemaker which I acquired will carry me about five years beyond my life expectancy and, as my old Pappy told me years ago, 'You can't be a sissy if you want to grow old.' " Burt still gets around as consultant for a few small financial companies, and finds that change is the only permanent thing he encounters. He attended the October Alumni Council meeting, the largest ever held — 260 attending. (I hope all readers know that any alumnus is welcome to attend these meetings of the council, even those out-of-towners who happen to be in the area.

We have some news from **Jim Turner**: he and Edna were preparing for a trip to Maine last October to see their niece when Edna had a bad fall and shattered her right shoulder. She was to start therapy in November after two weeks with the traditional mobile sling. He continues, "We bought into a condominium that we had been looking at last spring in the Boca Highland Beach development, but it won't be ready until next June and, for practical purposes, will not be occupied until October." For 30 years I have been casually keeping an eye on the many new developments, so after arriving in Florida this year I rode up along the coast to the north end of Boca, and right away I spotted the two new big high rises. So Leona and I have a new neighbor coming soon, less than six miles north. I hope that all neighbors are half as nice as this pair.

We have a short but pithy note from **Cal Mohr**, our Senior Vice President from Pennsylvania. Cal wrote a letter to **Neil Hopkins**, earlier, and Hoppy wrote a return letter reporting that he had headed the York, Penn., Alumni Fund for several years, and did real well: they were first one year and second another, based on the contribution scale. . . . We have an especially nice note from **Ben Lieberfarb**, who reminds me that we sat at the same table for the Alumni Luncheon, which I

forgot to mention somehow. Ben has been in the field of physical education since graduation, and has taught at many schools and colleges in the Boston area. Though recently retired, Ben's recent assignments have been at Boston State College and the Center for Continuing Education at Northeastern University. He still does some consulting with the Massachusetts Office of Education. . . . Doctor **William Harper** writes that he has a disease called "hypoglycemia," which causes dizzy spells, which is why William dared not drive to the 45th.

We have only one Alumni Fund capsule, this from **Charlie Quick**. Charlie came down with a bad case of the flu a few days before the 45th, and had to cancel his reservations. We missed him.

Please note that I use the New Hampshire address below; I do insist that the Institute use that address. My Florida address (for classmates only) is 1079 Hillsboro Beach, Pompano Beach, Fla. 33062. All friendly greetings from Leona and me, from the heart. — **Warren J. Henderson**, Secretary, Fort Rock Farm, Drawer H, Exeter, N.H. 03833

34

News is slim this month, so I was happy to see an article in one of the Boston papers about Capt. **George Cunha**, U.S.N. ret. I don't know much about how he went from an M.I.T. graduate to a retired Navy captain and finally to his present work, which is what I am familiar with. At any rate, Capt. Cunha is one of New England's (if not even a wider area) experts on the restoration and preservation of old documents. He is now Director Emeritus of the New England Document Conservation Center in Andover, Mass. The particular article concerned the discovery, in Concord N.H., of mint condition parchment originals of the Bill of Rights and the 11th Amendment, and an 1823 engraved copy of the Declaration of Independence. Capt. Cunha was called in to help authenticate and evaluate the documents.

I have one alumni fund note from **Elizabeth M. MacGill** who has her own consulting firm in Toronto. It outlines an impressive set of honors that came to her in 1978 including: the Queen's Silver Jubilee Medal; a Doctor of Science Honor's Course at an engineering convocation at Queen's University, Kingston, Ont.; and a similar honorary Doctor of Science degree at the Atkinson Convocation at York University, also in Ontario. Such a flow of honors are testimony to the high standing Ms. MacGill must enjoy in the Canadian scientific community. — **Robert M. Franklin**, 620 Satucket Rd. (P.O. Box 1147), Brewster, Mass. 02631; **George G. Bull**, Assistant Secretary, 4601 N. Park Ave., Apt. 711, Chevy Chase, Md. 20015

35

Ned Collins, now known as "the professor," writes: "Reading the *Review* made me realize that it's been ages since I have made any effort to help you fill out the '35 class notes. So, here goes and I hope it reminds others to do likewise. First of all, on behalf of the 27 hardy golfers present for the 18th annual class golf tournament, let me say 'thanks a million.' We all appreciate your work on that event. Thank the Lord you love golf the way you do!

"My congratulations to **Bill Bates** for winning our tournament three times and retiring the cup. With his handicap, it is one helluvan accomplishment. I am glad he won this year because next year I will be the 'dark horse' to beat, particularly after being nominated 'sand-bagger of the year' by my club members. We all realize that your new business responsibilities prevent you from golfing with '35ers all over the country. You will be missed, I'm sure, but at least it gives us local hackers a chance to get some of your 'Yankee money.'

"For the past year and a half I have been semi-retired. I found it boring having nothing to do, so this semester I'm a visiting lecturer at Southeastern Massachusetts University Construction Technology. I'm finding it to be a real workout after 43 years away from the books but a lot of fun as well."

I had a card from Bill Bates who is spending three months in Mexico City: "I hated to have the season end. I played nine holes the day before I left and shot a 42. I'll start all over in the spring and try harder. I'm glad you are feeling good; maybe next year you can make Pittsburgh for a game or two. Have a good winter."

Last summer the Peterborough, N.H., *Transcript* had a photo and detailed story on **Bissell Alderman**'s work installing solar heating in the summer home they purchased from Dean Emerson at M.I.T. . . . In a brief note from his widow we learned that **James W. Endress** died on August 11, 1978. I am extending the sympathy of his classmates to her. . . . To end on a pleasanter note: Doreen and I have just returned from a five-day trip to Puerto Rico, celebrating our 25th anniversary. It's a beautiful and relaxing place with its lush tropical greenery, pina coladas, golf courses and sandy beaches. We stayed at Palmas del Mar on the southeastern coast outside Humacao, soaked up sun between five-minute showers, played some golf and met lots of nice people. It was hard to return to snow country. Bear up and drop me a line or two. — **Allan Q. Mowatt**, Secretary, 61 Beaumont Ave., Newtonville, Mass. 02160

36

Here's another installment from the mail bag: **Gerry McMahon** from Lake Charles, La., reports the impending marriage of their youngest daughter. Gerry retired from Cities Service last August and recently moved into a larger house; he is busy with local activities and his hobby of photography, spurred on by a retirement gift of a new camera. He has been working on geneology and using this research as a reason for extended travel. He and Catherine hope to return to New England and Nova Scotia this spring. . . . Another Gerry, **Gerry Chapman**, sends greetings from Mill River, Mass. In his retirement he is researching and writing a biweekly column on local history for *The Berkshire Eagle*. Gerry lost his wife, Alice, this past summer and his daughter, her husband, and her five-year-old daughter are living with him. . . . **Al Gray** checked in from Holmes Beach, Fla., where they moved following his retirement from Exxon in December, 1977. They did try California first but settled on Anna Maria Island, 50 miles south of St. Pete, and would love to see any classmate who passes that way.

The Reverend **Claxton Monro** of St. Stephen's Church in Houston, Texas, is going full tilt — I will share his interesting letter with you. He writes: "I am still an Episcopal clergyman, still married to Vicky — since 1943 — and still the father of three women and one man. But only recently have I become the grandfather of two. I am still learning through doing as a pastor, having been here since July 4, 1950. How grateful I still am for the business training I received in Course XV. One reason I have been able to stay creatively at St. Stephen's has been due to my ability to succeed in the financial management of the congregation's life. My M.I.T. training has also helped me to make important discoveries through applying the scientific process to church life. Since 1954 I have been an articulate radical, calling for renewal and upheaval in the Christian community. Now I can see that seeds sown as long ago as 25 years are bearing much fruit." Looking ahead he says "our first task must be to help people find and grow in healthy, happy, enduring love relationships with others — starting with an enduring happy love relationship with God in Christ. This seems to be a time when many people will rejoice at the opportunity to have a part in such a Church!"

Another far-from-retired classmate is **Laddie Reday** who sends a postcard from the Australian outback near Alice Springs followed with a reprint of an article he wrote for the *Orange County Illustrated* entitled "Patter of Mountain Boots in Patagonia." In between travels he admits to having to do some work! What's that?. . . . Well, in between sessions of writing class notes your Secretary occasionally does some work too. As I write these notes on a very inclement Saturday morning I am mulling over a "sermon" I have written for presentation in New Haven tomorrow. I could have used some help fm Claxton.— **Alice H. Kimball**, Secretary, P.O. Box 31, West Hartland, Conn. 06091

37

O. William Muckenhirn writes that after ten years in academic administration as chairman of the electrical engineering department and acting dean of the graduate school at the University of Toledo, he has returned to teaching and research and is enjoying it. His youngest will be a junior in electrical engineering at the University of Toledo.

Rose and **Bob Thorson**, after 18 years of apartment living, have just completed and have moved into their new home in Winchester, Mass. Bob is still president of the Thor Roofing Co. and also keeps busy as vice president of the Lawrence Memorial Hospital in Medford, Mass., member of Rotary, director of the Hillside-Cambridge Cooperative bank and director of the Winchester Country Club in Winchester, Mass. Bob recently received the "Citizen of the Year" award presented by the Medford Chamber of Commerce. Both Rose and Bob curl in the winter and play golf during the rest of the year. — **Robert H. Thorson**, Secretary, 506 Riverside Ave., Medford, Mass. 02155; **Lester Klashman**, Assistant Secretary, 198 Maple St., Malden, Mass. 02148

38

I reported last month that I saw **Dave Wadleigh** in Chatham, Mass. Follow-up on that: I just read that Dave got a building permit to put up a house there. It looks like Chatham will become a retirement center for at least some of us in the Class of 1938.

A letter from **Don Severance** reads: "While I was in Minnesota, **Bill Whitmore** dropped off a Lockheed photograph showing him with the cup presented to him by the M.I.T. Corporation for seven years' service on the Corporation Visiting Committee for the Department of Mathematics. Bill also left a copy of a letter from **Russ Coile**. Russ and Bill are in constant contact in connection with the Operations Research Society of America; Russ organized a couple of sessions on operations research for a recent meeting in Los Angeles and has been invited to be on the editorial advisory board of a new journal, *Scientometrics*." **Demetrius Jelatis** and I had lunch last October. He is doing a fair amount of travelling as vice president and one of the three principals of Central Research Laboratories in Red Wing, Minn."

William Whitmore, '38

Ed Hadley has written some interesting letters, one of which starts out, "As I sit in my air-conditioned living room of my three-bedroom house contemplating my life of luxury, I pause to feel sorry for all you poor people out in the cold, cold world dreading another cold winter. It's beautifully warm during the day without a cloud in the sky and comfortably cool shirtsleeve weather in the evening. Commuting distance is about 100 yards and the dining hall about 100 feet from the office." The fact is that Ed is a cop-out — he didn't

want to spend the time necessary to finish up our 40th Reunion book, and so Western Electric sent him over to Saudi Arabia. There he is in charge of coordination, central control, design engineering, and contract administration for microwave route construction in the Kingdom. From his comments, it also makes him the head janitor. — **A. L. Bruneau, Jr.**, Secretary, 412 Ponfield Place, Ridgewood, N.J. 07450

39

Holden Withington lectured recently at an M.I.T. aeronautical symposium on "What to Expect in Aviation During the Next 30 Years." In the meantime Holden continues at Boeing as Vice President heading engineering operations of the commercial company and he plays a major role in completing the many orders placed for new aircraft. After having built large airplanes all his life, Holden is now learning to fly the smaller ones and he has logged more than 40 hours in a Cessna 172. . . . **Hans Bebie** is head of Central Engineering at Boeing, and he manages to sail now and then on Lake Washington in a boat he and Holden Withington jointly own.

Bascom Emerson is Vice President in charge of the automotive division of the Gates Rubber Co. Emmie reports he spent a pleasant evening recently with **Dick Cella** in New York, and he may do a bit of golfing and quail hunting in Texas soon. . . . **Eli Dannenberg** completed one year at Georgia Institute of Technology as senior research scientist and he has returned to his Cape Cod home from which he travels as a consultant to the carbon black, rubber, and plastics industries.

Al Laker and Edna make their home in Glendale, California. Edna enjoys the stimulation of being principal of a junior high school. During the week before Halloween Al flew to three states in the East where he made some high-level inspections. He didn't say whether they were to be made on structures of skyscrapers in connection with his training in Course I or whether they were made in board rooms where some flights are also at high level. Al and Edna are planning to visit us here in two weeks and we hope they'll bring some news items to relay along to you. **Ernie Kaswell** and his associates developed a company which was acquired during 1972 by Albany International Corp., the world's largest manufacturer of papermaker's felts. Their products cover some 95 per cent of all the tennis balls made in U.S.A.

Colonel **Peter Shunk** experienced a heart attack during May. On June 20 a pacemaker was installed and his recovery is proceding according to plan.

Ernest Kaswell, **Donald Waterman**, **Paul Stanton**, **Robert L. Frank**, and **Peter Shunk** are giving extra time on behalf of the Alumni Fund.

Aaron White reports that a committee including **Seymour Sheinkopf**, **Fred Schaller**, **Ernie Kaswell**, and **Manning Morrill** has made solid progress toward arranging our 40th class reunion. Each class member will receive a letter with full details, probably before this news item appears in the *Technology Review*. In responding to the special questionnaire, our classmates voted five to one to hold our 40th reunion near the Cape. Aaron says our reunion activities will start Thursday, June 7 with a Pops Concert. Lunch Friday will be at the Institute. Convenient door-to-door transportation has been arranged for Friday afternoon from M.I.T. campus to the modern Harbor View Hotel at Martha's Vineyard where we'll have dinner Friday evening. Saturday's activities will include swimming, tennis, golf, a clambake, and a moonlight sail. On Sunday we'll be returned to M.I.T. campus. The committee has done a great job to arrange so much so soon, and it would be helpful for all of us to respond most promptly. Send your class dues of $15 and your commitment to attend to **Seymour Sheinkopf**, Reunion Chairman, 205 Wolcott Road, Chestnut Hill, Mass. 02167. And, for expert advice on how to gracefully and effectively open clams, crabs, and lobsters, write Jean and **Joe Dana** whose demonstrations in those areas during our reunion at Bald Peak Lodge were most impressive. — **Hal Seykota**, Secretary, 1421 Calle Altura, La Jolla, Calif. 92037

40

The Happening. **John Danforth** sends his first report on the 40-40 Reunion. The reunion committee includes **James L. Baird**, **Edgar L. Bernard**, **Sally Bittenbender**, **John L. Danforth**, **Maurene Feldman**, **H. Tyler Marcy**, **Philip A. Stoddard**, **Edward J. Kingsbury** in Massachusetts, **Thomas F. Creamer** in New York, **John J. Casey, Jr.** in Texas, **Russell L. Haden, Jr.** and **Phelps A. Walker** (Class Agent) in Georgia, **Norman R. Klivans** (vice president) in Missouri, **M. Arnold Wight, Jr.** in New Hampshire, **George Kaneb** in Montreal; as well as **N. Bruce Duffett** (president) in Pennsylvania, and **Frank Yett** (secretary) in Washington, wintering in California.

We need wider geographical representation for our 1980 reunion planning — Jack Danforth seeks additional committee members. In addition to 1980 reunion plans, late 1979 or early 1980 mini-reunions are being suggested for such cities as Chicago, Dallas, Los Angeles, San Francisco, and somewhere in the Southeast or Florida. These meetings will follow the first of the mini-series now scheduled at Hershey, Penn. on October 19, 1979, with **Bruce Duffett** in charge. Suggestions regarding the format, time and location of these earlier regional reunions as well as the June, 1980, gathering should be directed to this column or sent directly to **Jack Danforth**, 35 Farm Lane, Westwood, Mass. 02090.

The on-campus part of the reunion will be Thursday and Friday, June 4 and 5, 1980. The activities on campus will include the Class of 1940 Gift to M.I.T. (the gift campaign is being directed by **Phelps Walker**). From June 5 through 9 an off-campus celebration is scheduled. Reservations have been made for the Lighthouse Inn, West Dennis, Mass., on the south shore of Cape Cod. Wentworth-by-the-Sea near Portsmouth, N.H., is being considered as an alternative to the Cape site.

Executive Suite. **William E. Leonhard**, president of The Ralph M. Parsons Co., will continue in that position as he becomes chairman, president, and chief executive officer of the newly formed Parsons Corp. He says, "The creation of a holding company will provide a corporate structure that will permit organizational and operational flexibility more in keeping with Parsons' present and future plans of operation." The Ralph M. Parsons Company, as well as DeLeuw, Cather & Co. (Chicago) and S.I.P., Inc. (Houston) are now subsidiaries of the new corporation.— **Frank A. Yett**, Secretary, 1405 Ptarmigan Drive, Walnut Creek, Calif. 94595

44

For us who lived through the Big Blizzard of February 6, 1978, this month will always be suspenseful, and no groundhog will be able to change that. (Anyway, a beaver would be more reliable!)

Beavers have been congregating. Since our last report, we have attended two M.I.T. gatherings, each different but both adding to the spirit of school and class in unexpected ways. We didn't have so strong a class spirit in our undergraduate days.

On November 16, the Reunion Committee met at the home of Priscilla and **Robert Breck** to share their warm hospitality while we made further arrangements for our 35th Reunion in Bermuda. Gathered at the Brecks were: Marguerite and **Ed Ahlberg**, Anita and **Les Brindis**, Ruth and **Norm Sebell**, Edna and **Stan Warshaw**, and your secretaries. We were visited by Ann Perry, of Joe Martori's staff in the Alumni Association. She shared with us many facts about reunion procedures and on the practices of other classes.

Several matters were decided. In response to requests from classmates, there will be provision for friends of alumni to join us in Bermuda, unless the accommodations are filled by alumni and family. The closing date for reservations will be approximately April 1. At M.I.T. there will be the regular pre-Pops buffet, followed by the Tech Night Concert at Pops, and a beer and pizza party, for the Class of 1944. Some classmates may choose the Cambridge based activities only; some may opt only for the Bermuda trip; some like us, will be at both. Please join us and let **Norm Sebell** know. The whole package, Cambridge plus Bermuda, has been held to less than $500 per person.

Two days after our class meeting, we received a fascinating phone call from **Paul Robinson**, Class Treasurer and former Class Secretary. He called from Washington with information we needed on procedures and protocol. After all, Paul is a Certified Parliamentarian. Somehow we got around to hearing more on the famous story about how Paul successfully challenged an unjust traffic ticket and won out against the federal court system — kept the $10 fine — then Paul had to sign off to watch a television show on the activities of the Washington chapter of Fathers United for Equal Rights — featuring Paul!

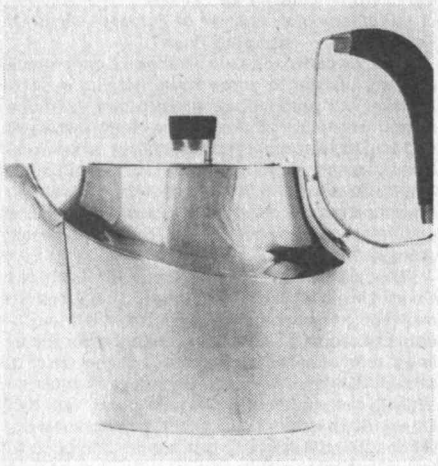
When he called later, he arranged a conference call (we hesitate to guess how) bringing in **John Barmby**, our predecessor as secretary. We hope to get John's file of class notes. Before the call had ended, we had persuaded them to come to Bermuda with us. (We're bound to need a parliamentarian and a Ph.D. in Public Administration.) It was quite an event and we'll always remember that telephone conference of four class secretaries.

The next official class meeting was the Alumni Council in November at the Faculty Club. Because many of you own your businesses, the topic — entrepreneurship — would probably have stimulated many comments had you been able to attend. Three speakers addressed different aspects of the subject. It was a delight to hear Ken Olsen, '50, president of Digital Equipment Corporation, talk about keeping it human. It's good to know that there are progressive executives who value the innovative individual. There were four members of our class at this meeting: **Bob Jevon**, **John Taft** and the two of us.

Earlier in these notes, class spirit was mentioned. It was during the Thanksgiving holiday that an M.I.T. student asked why our class seemed to have as much spirit, cohesion or self-identity as we described to her. Tough question, and answers keep building. One reason is that the war years brought some of us into more intimate contact for a longer period than peacetime classes could expect. There were R.O.T.C., V-12, accelerated Institute programs, and "Rad-lab" urgencies. However, there must be more to it. Perhaps it takes a quarter of a century, percolating through an industrial society, for an M.I.T. class to realize the special nature of the Institute and of the persons who attend it. There is something special about a Tech undergrad — and after a while each of us takes full pride in that fact. Later reunions become more memorable. The 34th mini-reunion at the Tides Inn was so pleasant for us that we really look forward to the 35th. We often open that marvelous book that **Stan Warshaw** and **Lou Demarkles** put together for the 25th Reunion. Usually we go to it to check on some fact or report but we always linger as we flip through; more memories per page than most books. (Maybe we'll start campaigning for yearly reunions. Of course we're spoiled; here in the Boston area we've been enjoying monthly mini-reunions as the Reunion Committee.)

Our class unity seems to transcend geographical and political boundaries. An example of this was brought out by recent announcements. In the November issue of *Technology Review*, six of our classmates were listed in the obituary column, all with the same date of death, all with Turkish names. In the notes for that issue we had tried to explain, but were way off; that's why that write-up was deleted. The *Review*'s staff later explained that the "same date" phenomenon reflects the date of the administrative survey of the overseas alumni. The point is that we were concerned, and that we investigated as best we could; thirty years

William N. Frederick, '46 (right), aeronautical engineer turned artist, creates chalices, jewelry and decorative motifs of silver in his Chicago studio. (Photo: David Nystrom, Chicago Tribune*) The teapot (below) is of silver and ebony and was designed and made by Mr. Frederick in 1960. (Photo: Chicago Historical Society)*

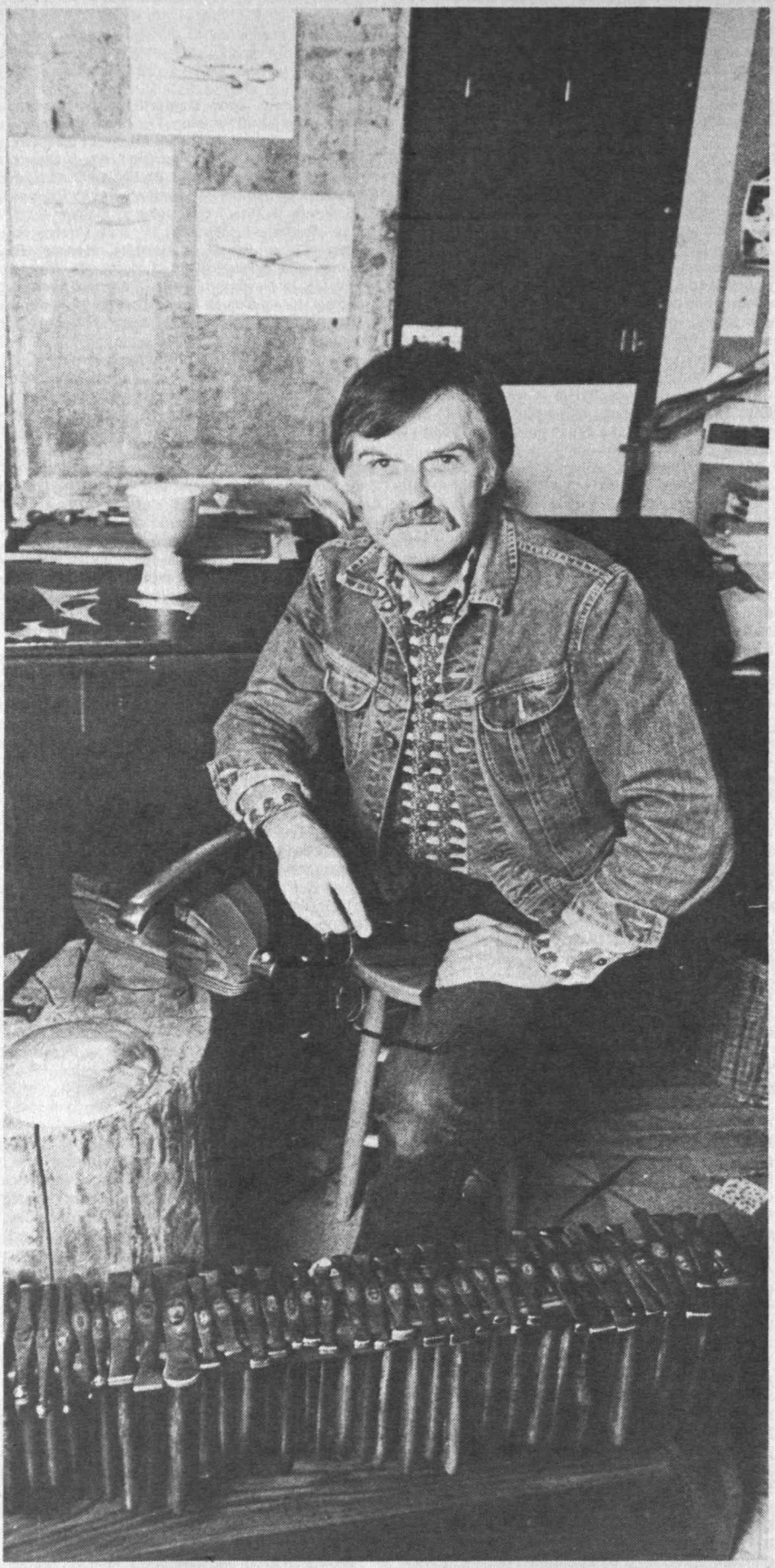


Teapot Takes Off

How is a teapot like an airplane? No, this is not a riddle from *Alice in Wonderland*, but rather an explanation for why an M.I.T.-trained aeronautical engineer becomes a renowned metalsmith.

Sometimes called a "white-collar drop-out," William N. Frederick, '46, says he turned to silversmithing because "nothing delights me more than attempting to solve an intimate design challenge within the limits that are brought to me."

Mr. Frederick, who teaches metalworking at the Loyola University of Chicago, works out of his studio and creates streamlined, modern designs, some of which have been exhibited at the Dallas Museum of Fine Arts, the Smithsonian Institution and the Art Institute of Chicago. He refers to his craft as "man in pursuit of perfection." "But," he says, "it's the inevitable imperfections which give handwork its warm personal value."



ago we might not have noticed.

In the Northeast part of the U.S.A., warm days in February remind us that spring is on the way. To the skier, such weather is a reminder of a quickly ending season. But, no matter where you are, we hope you find some kind of weather to your liking. — **Melissa** and **Newton Teixeira**, Co-Secretaries, 92 Webster Pk., West Newton, Mass. 02165

46

I do hope all of you had a very nice holiday season and I wish to add my belated wishes to everyone.

We are suffering from a tremendous lack of information from the class members. Please write us a short letter outlining your activities, work, family changes, etc.

E.W. Sellman has been kind enough to write us and we are pleased to include his report: Mr. Sellman is chief of the program technical branch, Office of Environment and Energy, Federal Aviation Administration, Washington, D.C. Mr. Sellman's primary effort is concerned with aircraft noise monitoring systems and the environmental impact of aircraft. He is currently working on noise studies of the Concorde supersonic transport. E.W., his wife, Sidney, and their three teenagers live in nearby Vienna, Va.

The past years have been very active and productive for our **Ernie U. Buckman** of Pittsburgh. Ernie is president of Oliver Realty, Inc., of Pittsburgh, a company that manages and leases real estate, designs and constructs buildings, appraises and consults on real estate matters and buys and sells real estate. Many of the people that work at Oliver Realty bought it from Oliver Tyrone in 1976. In 1977, Ernie sold his 49 per cent of Oliver Realty to 28 of his fellow employees. As we mentioned, he continues as president of Oliver Realty and is also a member of the board of directors. Recently Ernie purchased a 50 per cent interest in a second home at Sea Island, Ga. He is a grandfather now with two grandsons, aged 2 and 5, living in Chatham, N.J. . . . Until next time, — **Russell K. Dostal**, Secretary, 18837 Palm Circle, Cleveland, Ohio 44126

47

Joe Devaney, writing in the September, 1978, *Physics Teacher*, points out and substantiates some strong claims in his article, "Physics-Related Problems of Coal-Fired Power Plant Pollution," written under the auspices of the Department of Energy. "Indeed the hazard from coal-fired power plants alone is considerable and might even be so severe and so difficult to control that it would be advisable to ban open coal burning altogether, as is effectively done presently in Los Angeles. In comparison with a power system that some consider extremely hazardous, per kilowatt-hour of electricity produced, the coal power cycle is orders of magnitude more toxic to humankind than the *total* fission cycle. In normal operation the relative air-borne effluent risks, coal versus nuclear fission, can be as high as 18,000 or more. Coal also has considerable radioactivity from its impurities, so much so that the radioactive hazard alone from burning coal exceeds that released from fission reactors in normal operation for the same power produced. Furthermore, . . . the radioactive toxicity from coal ash is greater than that from the sum of *all* the fission products after 500 years, for the same power produced." Joe shows that air pollution is a problem in rural as well as urban areas and suggests emission control as the sensible approach.

Vernon Sholund is still "in the camp of the enemy." He is a consulting mathematician at J.P.L. exploring laser applications to fusion research.

In September, Rear Admiral **Wayne Meyer**, AEGIS Shipbuilding Project Manager, announced the contract award to Litton Industries for the detail design and construction of the first AEGIS equipped guided missile destroyer of the DDG-47 class, "the most broadly capable, heavily armed and survivable destroyer the navy has ever built." Wayne enlisted in the navy in 1943, was commissioned an ensign in the reserve in 1946, and was transferred to the regular navy in 1948, after receiving an S.B. in electrical engineering. He proceeded through the ranks in jobs that took him around the world, pausing to become one of the first Naval officers to earn a master's degree from M.I.T. in astronautics and aeronautics in 1961. In 1975 he was selected for flag rank. His current assignment vests design and construction responsibility for both the AEGIS ship and combat systems in a single project manager, and represents a major post-merger decision by the commander of Naval Sea Systems Command. Wayne is an outspoken proponent of seapower, has authored many articles on tactical missilery and surface ship combat system design and development, and has served on and headed numerous technical panels and boards in the Department of Defense and industry.

Arthur Schwartz has agreed to accept the job of estate secretary for the class.

Love to all. — **Ginny Grammer**, Secretary, 62 Sullivan St., Charlestown, Mass. 02129

48

At our 30th Reunion, the Class of '48 elected officers and after the election, **Graham Sterling**, our new president, appointed the class agent and the chairman for our 35th Reunion. In addition to Graham, the following classmates were elected or appointed for the next five years: Secretary, **Marty Billett**; Treasurer, **George Clifford**; Vice President at Large, **Sonny Monosson**; Vice Presidents for Greater Boston, **Leon Lafreniere**; Greater New York, **Ken Brock**; Greater Chicago, **Mitch Silverstein**; Southwest, **Tom Pawel**; West, **Bill Zimmerman**; Assistant Secretaries, **Bob Sandman**, **Lou Kreek**, and **Jack Page**; Class Agent, **Warren King**; 35th Reunion Chairman, **Don Noble**; and Class Estate Secretary, Ken Brock.

I am proud to be elected secretary for the third time, and I hope I can serve our alma mater and our class in an exemplary manner.

In June I resigned from Facet Enterprises of Tulsa, Okla., where I was internal consultant for manufacturing. Facet was created by combining divisions of Fram Filters and Bendix to form a new company with 2,500 employees. I enjoyed 16 years with Fram and 3½ years with Facet. In July I became manager of technical operations for Globe Manufacturing Co. in Fall River, Mass. Globe is a leading manufacturer of rubber thread and spandex fibers which are extensively used in elastic fabrics for sock tops, men's undershorts, panty hose, girdles, bras, and body stockings. Globe makes spandex fibers (in a wide range of deniers) which are either knit alone or with another textile fiber in our customer's knitting machines. Technical operations at Globe include three groups to develop, optimize, and control raw materials, process machinery, operating conditions and product properties. Dick Miller, '54, heads up process development which has designed and built the majority of the extruders, ovens, and winders. The research and development group includes several chemists who develop new polymers and optimize operating conditions; quality control, process control, and engineering provide the coverage for the three-shift-seven-day operation required when extruding fibers. About 100 people are employed in technical operations and 200 in production and related activities. I am responsible for direction and coordination of all technical operations at Globe. We operate manufacturing plants in Fall River and Gastonia, N.C., and a subsidiary in England. Our daughter Amy is a senior at Yale, and our son Larry has joined Pan-Am as manager of scheduling for the Atlantic region after two years with T.W.A. Cliff graduated from Syracuse and is with American Airlines as a market analyst in the Scheduling Department.

G.T.E. has announced that **John C. Avallon** of Beverly became president of G.T.E. Lighting Group on October 31st. The G.T.E. Lighting Group, which has 18,200 employees in 41 plants and 9 laboratories in 12 countries, is a leading producer of lighting products for residential, commercial, industrial, and photographic use. John will continue to have his headquarters at the Sylvania Lighting Center in Danvers, Mass. John has been president of the G.T.E. Precision Materials Group since it was formed in June, 1976; he joined Sylvania as a microwave power tube engineer in 1952 in Salem, Mass. He was named General Manager of the Sylvania Lighting Equipment Division in 1964 and later was vice president for research, engineering and special products for the Lighting Group.

Rear Admiral **Elmer T. Westfall**, U.S.N. (Ret.), of Sullivan's Island, S.C., received the A.S.N.E. Gold Medal Award in recognition of significant, overall contribution to the field of naval engineering, and especially "for outstanding professionalism and leadership in developing and executing unique philosophies and techniques in the overhaul of ships of the U.S. Navy during the period 1974-1977." Among his military decorations, Admiral Westfall holds the Meritorious Service Medal for his performance as submarine ship logistics manager and the Distinguished Service Medal for his outstanding performance while commander of the Norfolk Naval Shipyard.

George Wayne received a Bronze Beaver from the Alumni Association in October. George has been a leader of alumni activities in Florida and on the national level and spearheaded the development of new clubs and new programs in southeast Florida. The citation noted that George's loyalty, dedication and enthusiasm for alumni activities is both exemplary and infectious.

Fred Bailey is president of Teledyne Engineering Services in Waltham. He has been active in Lexington, Mass., community service as former chairman of the Board of Fire Commissioners and former president of the Board of Trustees of the Public Library. . . . **Stanley Palmer** was presented a meritorius service award by the Association of Physical Plant Administrators of Colleges and Universities in recognition of his work as chairman of the Association's Energy Gommittee, where he has helped develop programs to help colleges and universities in energy conservation efforts.

Pete Richardson, director of admissions at M.I.T., has been appointed to the College Board's Council on Access Services. The Council is concerned with developments, trends, and issues related to early guidance and career planning for recent high school graduates. As a Council member, Pete will review programs and services of the College Board and advise the staff and trustees on how these can best meet the needs of both institutions and individuals.

Dr. and Mrs. **Alan Kay** were among the sponsors of a benefit for the Boston Center for the Arts.

1978 has been a bumper year for harvesting degrees for the **Herbert Kindler** family: David, 21, graduated from M.I.T., Course II; Peggy, also 21, received a Bachelor's degree from Penn State; Alex, 25, earned the M.B.A. from Pitt; and Herb received his Ph.D. from the U.C.L.A. Graduate School of Management. Herb is currently teaching management at Whittier College. — **S. Martin Billett**, Secretary, 16 Greenwood Ave., Barrington, R.I. 02806

49

The first two weeks of replies to our first 30th Reunion mailing, ending December 18th, have added 36 letters to our pre-Christmas mail. These include 22 plan-to-comes and 12 hope-tos. Seventeen are going to Bermuda; eight people specified Cambridge only; the remaining nine didn't indicate. Here are the early-bird names: Roz and **Stan Margolin**, Sonya and **Frank Hulswit**, Jean and **Harry Lambe**, Mary and **Peter Lehner**, Eunice and **Joseph Schneider**, Jeanne and **Charles Sutherland**, Norma and **Minas Deranian**, Virginia and **Paul Weamer**, Doris and **Malcolm Kurth**, Frances and **Francis McCarthy**, Diane and **Dave Hardin**, Patricia and **Warren Houghton**, Marlene and **Emilio Venegas** (and Kim, 17), **Al**

Innovation and Entrepreneurship: Learning by Example but Not by Rote

How did Kenneth H. Olsen, '50, the successful entrepreneur behind Digital Equipment Corp., really do it?

By being himself turned on, by finding bright people to work with him and giving them freedom, by putting emphasis not on growth as a goal but on doing a good job, and by capitalizing on an important new concept before anyone else could do it.

This prescription for successful entrepreneurship came from Mr. Olsen at a meeting of the Alumni Advisory Council late last year devoted to how M.I.T. and its alumni can help students and other alumni turn good ideas into entrepreneurial successes. It turned out to be a frustrating — but intriguing — question for Mr. Olsen and his fellow-entrepreneurs on the panel — John W. Jenkins, '43, President of Planaflex Co., and Francis F. Lee, '50, Professor of Electrical Engineering and Computer Science.

Building on Trust

The idea of starting a company hadn't occured to Mr. Olsen when he first graduated and went to work at M.I.T.; he was busy and happy working on computers, and he remembers marvelling to himself that "they let you do all this and pay you too."

But the entrepreneurs among his friends were kidding him: was he going to be an academic all his life? So Mr. Olsen took his ideas about simple, small, interactive computers to American Research and Development and came away with $70,000 on which to start the company; those were the good old days: "We did everything ourselves," and the $70,000 was small enough so that "you could watch every one of them."

In addition to the technology, Mr. Olsen took an important lesson in management away from the Institute: M.I.T. has "an attitude of trust which I've seen nowhere else," he said, "and we've tried to take it with us." In D.E.C. this idea takes the form of "getting bright people and giving them freedom."

Putting a Lid on Growth?

D.E.C.'s first goal, Mr. Olsen said, was no growth *per se* but producing a good product. "We knew growth would come if we did a good job." And come it did; within a year one of his friends was warning Mr. Olsen that "no one has succeeded this soon and survived." Ever since then slowing down growth, "keeping the company under control and understanding it" has been one of Mr. Olsen's jobs as chief executive. His rule of thumb is that growth shouldn't exceed 50 per cent a year — 'that's hiring two new people in a group of four," he explained.

Why this lid on growth? Because the larger a company, the harder to keep the spirit of individual freedom alive within it. "You have to work at it constantly," said Mr. Olsen, "combatting the tendency that people have of wanting freedom but not giving it.

"The key is to convince people that some of their subordinates may know more than they do, to let someone do something that seems to other people to be less optimal."

All this sounded good to Professor Lee: 'We're all entrepreneurs at heart — it's a matter of timing and incentive." But can you deliberately set out to be creative, or teach a student to be innovative? asked an alumnus. That question gave the panel pause, and in the end the answer came from the audience, too: "As soon as you try to answer a question you haven't been asked, you get in the way," said Myron C. Tribus, Director of the Center for Advanced Engineering Study. — *J.M.*

Levingston, Munya and **John Miller** (and Lisa, 21 and Jack, 18), Zelda and **Nathan Sokal**, Gary and **James Veras**, **Ray Larson**, Jean and **Robert Lincoln**, Martha and **Joseph Lynch**, Marjorie and **David Moore**, Gloria and **Herb Spivack**, Mary and **Jack Baker**, Dot and **Jim Christopher**, Betty and **Ira Dyer**, **George Haviland**, Shirley and **Chuck Holzwarth**, Norma and **Marvin Asnes**, Evelyn and **John Barriger**, Sara and William Hutchinson, Margaret and **Robert Breese**, Eleanor and **Bill Howlett**, Pam and **Mickey Ligor**, and Rhoda and **Kemon Taschioglou**. Who's next?

In response to a question by **Mel Kurth**, anyone may stay longer in Bermuda than the basic four-night plan, returning Wednesday. Several classmates plan to remain for the balance of the week, returning Saturday. You should receive (or have already) full information on options from our second mailing. **Joe Lynch** and others from LAX will be pleased to discover that there is a direct connection from Boston with less than an hour's lay-over — no need to go via JFK.

Bob Lincoln sent the following letter on the back of his form: "Dear Frank — It's been 15 years or more, hasn't it? And to state that it is 30 years since I was in Cambridge doing preliminary thesis work is, well, unbelievable. Be damned if I feel (or act) 52 years old. A bit of personal history: After I left Arthur D. Little, Inc., I was Chief Engineer at Narragansett until the brewery was sold to Falstaff (which in turn has been devoured). A lovely part of my life, Frank. Then various engineering and consulting jobs through the ups and downs of the late 1960s including a stint in England where I met one Jean Beckett, who became Mrs. L.; she came from St. Louis, where we came and where I've been Deputy Director of Public Works of the county for ages, it seems. We are as large in area as Los Angeles County with almost 100 political subdivisions, so professional life is stimulating indeed."

Two Alumni Fund notes this month: **Robert Griggs** writes, "I recently became a grandfather for the first time — Sandra Marie Demars, born to daughter Susan and her husband David J. Demars in Cleveland. Daughter Gayle married last December to Antonio Buso and living in Austin, Texas, where Gayle is a graduate student at U. of Texas. Son Charles going into the sophomore year in business administration at Carnegie Mellon University, worked this summer for Citibank in Puerto Rico and enjoyed the status of a junior executive — even worked on the budget! Planning a trip to England next month with oldest daughter Linda and her husband William J. Swedish. Linda is Special Counsel to the Associate Director of the Corporate Finance Division, Securities and Exchange Commission. I have an article coming out in *Tax Law Review* on the Puerto Rico tax exemption act of 1978." . . . **Len Newton** reports that he is an independent consultant in energy, electronic banking, and travel, based on 24 years in marketing and opinion research as vice president and director of Opinion Research Corp. and Response Analysis Corp. Among current projects: Concorde marketing and local-government energy conservation (for the Department of Energy); his specialty in financial services is consumer acceptance of electronic funds transfer. Ruby and Len have been taking a course in parenting from four teenagers: Julie (22) now on her own; Alex (20) ready for third year at Kenyon (psychology); Dave graduating from Princeton High School with accolades for choral performances at the Spoleto Festival (Charleston, S.C.), and Eric entering Princeton High School next fall. Len and Ruby would welcome seeing classmates passing through New York, Philadelphia, and Princeton. Len was founding President of M.I.T. Club of Princeton, which now has 100 members.

Sidney C. Howell, president and chief executive officer of the Weatherhead Co. in Cleveland, now operated as a wholly-owned subsidiary of Dana Corp. since a September, 1977, merger, has been appointed as group vice president — Dana Service Parts. New worlds to conquer! An article in *American Way*, October 1978: "Two Magazines, Two Editors, One Last Name" has a sub-title, "**Edward T. Thompson** may be following in his

father's footsteps, but he's wearing a very different pair of shoes." It describes how Ed became editor-in-chief of the *Reader's Digest* as follows: "The younger Thompson graduated from M.I.T. with a degree in chemical engineering and then worked for Mobil Oil. He explains: 'I decided I didn't want to be that kind of engineer anyway, so I got a job with a magazine called *Chemical Engineering* with the idea that I'd stay there for a year or two and find out what else a chemical engineer could do. But I ended up changing careers.' In 1956 he joined *Fortune* as a writer, stayed four years, and discovered that although he was successful he didn't enjoy writing. He migrated to *Reader's Digest*, served as managing editor from 1973 to 1976, and was then elevated to editor-in-chief. Both Thompsons maintain that there was no pressure on the son to follow in his father's footsteps. 'He wasn't the sort of person who would try to influence his offspring's career choice,' says the son. His father dismisses the question of influence by remarking: 'Well, I paid very high tuition bills to M.I.T. to make an engineer out of him.' "

That's it for this issue. Best wishes to all, and come to the 30th. — **Frank T. Hulswit**, Secretary, 77 Temple Rd. Concord, Mass. 01742

50

Don Harnsberger and family have moved from Moscow to London. He will continue to look after Cooper Industries' activities in the U.S.S.R. and other market developments in the oil and gas industry in Western Europe areas. . . . As of September, 1977, **August P. Doering** has been serving as market development manager for J.D. Warren's Graphic Products. . . . **Ken Olsen**, president of Digital Equipment Corp., headquartered in Maynard, Mass., has initiated a new phase in the company's marketing strategy — a retail computer shop. Digital, which dominates the small computer field, opened in a Manchester, N.H., shopping mall, the first of what could be several "showcase stores" throughout New England. — **J. T. McKenna, Jr.**, Secretary, 2 Francis Kelley Rd. Bedford, Mass. 01730 Class Secretary 1950

52

It has taken quite some time to accumulate sufficient news to write a column for the February issue. Please don't hesitate to write; this is the only way we can acquire news of what happens to you out there. . . . **Cliff Herdman** is one of those who believes in writing. He thoroughly enjoyed the 25th Reunion and his visits to the old dorm, Atkinson in the East Campus, and Walker Memorial, the scene of many a sterling basketball game. Cliff and his wife, the former Mary Walsh of the Bronx, N.Y., will be celebrating their 24th wedding anniversary next month. Their oldest boy is 21 and living in Boulder, Colorado. His two daughters are 19 and 18, and a sophomore in college and a senior in high school respectively. Cliff's youngest boy is 15 and quite a high school basketball player. Cliff is still with the Port Authority in N.Y. and N.J. where he has been since graduating, and is now a senior aviation planner. His most recent job was assisting the New York City Transit Authority with installation of an express subway to Kennedy International Airport. He is also coordinating master plans for Kennedy, La Guardia and Newark airports as part of a three year project under which the development of the three airports over the next 20 years will be outlined. At the end of his letter Cliff urges me to ask everyone who hasn't written in to write. In particular, what happened to **Bill Conville**, **Dick Ayers**, and **Ed Lawlor**?

Robert Astra has joined Creamer Dickson Basford Inc. in Providence, R.I., the largest public relations firm in New England. He is a technical communications editor. . . . The new chairman of the Business and Management Department, University Extension, University of California at Berkeley is **John F. Maxwell**. John is managing a group of professionals providing continuing education in Business and Management to the San Francisco Bay Area Business Community. John and his family went on a five month tour of the United States by trailer, after which he assumed his new post. . . . Loyola Marymount University has named **Edmund H. Shea, Jr.** to its Board of Trustees. Edmund is executive vice president and director of the J.F. Shea Co., headquartered in Walnut, Calif. The J.F. Shea Co. is an engineering, contracting and development firm with national contracts in heavy construction, such as tunnel and dam building. He is a member of the Development Council for Loyola High School, a member of the board of trustees of Mayfield Senior High School in Pasadena, and a trustee of the Santa Catalina School for Girls Foundation in Monterey. He and his wife, Mary, live in San Marino with their five daughters and two sons.

Tepper, Inc., of Bridgeport, Conn., founded in 1971 by **Harold M. Tepper** to design and construct conventional and pre-engineered steel buildings, has merged with Engineers, Inc., of Newark, N.J. . . . The Department of the Army has

Daniel L. Lycan, '52

announced that Colonel **Daniel L. Lycan** is the new commander and director of the Army Engineer Topographic Laboratories in Fort Belvoir, Va. The Engineer Topographic Laboratories' 273 civilians and soldiers attack military and civil problems in such diverse fields as dam safety, ecology, tank navigation, and missile guidance, using techniques such as electronic surveying, sophisticated photogrammetry, and automated mapmaking.

Colonel Lycan was formerly district engineer in charge of the Army Engineering District, Rock Island, Ill., and he has had numerous assignments in research and development, troop command, and military construction. He served as the Department of the Army representative to the Department of Defense Manned Orbiting Laboratory space program and commanded the Army Computer Systems Command Support Group at the Presidio of San Francisco. His early commands included the 84th Engineer Battalion (Construction) and the 45th Engineer Group (Construction); he was chief of the Engineer Operations Advisory Branch, Military Assistance Command while in Vietnam. Colonel Lycan has a bachelor's degree in civil engineering from M.I.T. and a master's degree and a doctorate in civil engineering from the University of Illinois. He is a graduate of the Army Command and General Staff College and the Army War College — **Arthur S. Turner**, Secretary, 175 Lowell St., Carlisle, Mass. 01741; **Richard F. Lacey**, Assistant Secretary, 2340 Cowper St., Palo Alto, Calif. 94301

54

W. Carleton Bartow has been promoted to director of real estate planning for Raytheon. In his new position, Carleton has staff responsibility for acquiring and managing the company's real estate. . . . **Perry Smoot** is conducting research on the detection and measurement of microshrink in nickel-base superalloys and its effect on properties at the Army Materials and Mechanics Research Center. He has also been evaluating a "thixocast" alloy made by Professor Flemings of M.I.T.'s metallurgy department. When not delving into things scientific, Perry enjoys kayaking on Lake Cochituate with son, Peter.

Paul Gray received a Bronze Beaver for "unselfishly devoting himself to strengthening the ties of alumni with the Institute while performing major leadership roles for M.I.T." Paul will be strengthening ties with classmates at our 25th Reunion in June. Will you be joining us? — **E. David Howes, Jr.**, Secretary, Box 66, Carlisle, Mass. 01741

56

Walter Bachman has been with Daymarc Corp. in Waltham, Mass. since 1966, where he was promoted last year to manager of research and development after being chief engineer for several years. Daymarc makes equipment for handling semiconductor devices, which is obviously a prosperous yet competitive industry. He is active in the Catholic Church's Charismatic Renewal Program and the Cursillo Weekend Retreats. His wife works at the Acton Corp. . . . **Ken Meliere** is a principal engineer in the Petrochemicals Group at Stone and Webster in Boston. He is also a Town Meeting member in Framingham, and has two children in the public schools there. . . . **Larry Hallee** of Acton, Mass. is also in the same group at Stone and Webster . . . **Richard Degenhardt** is still with G.E. in Pittsfield, but recently moved back into that city from suburban Worthington — after enough country life, he says. As program manager for Engineering Support in the Ordinance Department he works closely with the Draper Labs on the U.S. Navy Trident missile guidance system.

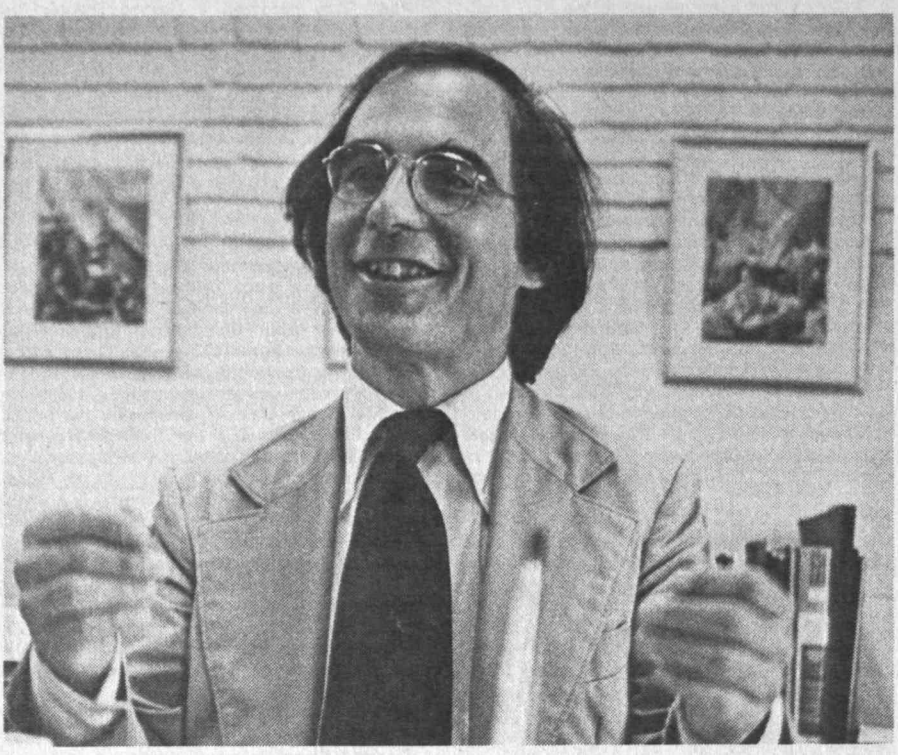
Martin Saltarelli has been with Beloit Corp. in Pittsfield, Mass. since graduation, and is now marketing manager of this manufacturer of paper making machinery. His children are now grown and gone, leaving him the time to be United Way Fund chairman this year. . . . **Martin Basch** is still (since his M.S. in 1958) with GENRAD (formerly General Radio) in Bolton, Mass., where he commutes on bicycle from Harvard, Mass. — all beautiful country he claims. He recently developed an electronic sound detector and analyser for monitoring noise pollution around airports and such. Martin and his colleagues keep in remote contact with the M.I.T. classrooms through the video tape courses distributed through the Center for Advanced Engineering Studies. His wife Betsy is the school nurse, so their two children (13 and 15) are no doubt healthy as well as quiet. — Co-secretaries: **Bruce Budehoft**, 7100 Lanham Ln., Edina, Minn. 55435; **Warren G. Briggs**, 33 Bancroft Rd., Wellesley Hills, Mass. 02181, (617) 235-7436

62

Richard A. Crowell, senior vice president of The Boston Safe Deposit and Trust Co., spends a goodly part of his time trying to improve computer technology as it might be applied to money matters. . . . *The Journal of Recreational Mathematics* will be having a special **Frank Rubin** issue in which all of the Problems and Conjectures are his own. . . . **Francis J. Berlandi** has been named chairman of the American Industrial Hygiene Association's Information System's Committee. Fran and Cheryl are enjoying the recent arrival of a son Aram Joseph. . . . **Kenneth Taylor**, "President, Pension Actuaries of the Delaware Valley (Social Organization), enrolled Actuary #1482, is treasurer of Sunday School Class, treasurer Faith Christian School P.T.A., matriculated at American College, 1977 — has passed five C.L.U. exams." — **Gerald L. Katell**, Secretary, 7 Silverbit Ln., Rolling Hills Estates, Calif. 90274

63

Greetings to all and a happy new year! Only one real news note this month and a few old press releases. **Thomas Bogan** writes that he and his wife, Beth, have two children. Nathaniel, age 7, is already a proficient snow skier, and now is



"Who cares if the President of Exxon has a fight with his Vice President?" asks Bernard A. Goldhirsh, '61. "That doesn't help me do my job better as the head of a small company." Acting on such a pragmatic philosophy, Mr. Goldhirsh has built first Sail *and later* Motorboat *and* Marine Business *into a successful stable of publications under the umbrella of United Marine Publishing Co. Now he's entering the business field with* Inc., *a magazine for small companies ($1 to $25 million) which will debut next spring. (Photo:* Boston Globe*)*

An Encore for Sail, Motorboat, and Marine Business? Try Inc.

An M.I.T. degree in mechanical engineering is not the obvious preparation for a successful career in magazine publishing, but Bernard A. Goldhirsh, '61, has all the right instincts: "Keep your eye on what the reader really needs," he says.

First applied to Mr. Goldhirsh's hobby of sailing, that formula led to quick success for *Sail*, which he started on a shoestring in 1970; now there are 170,000 readers — a "lion's share" of the market among those "purist" sailors who have no use for magazines that try to mix sail and power, says Susan Trausch of the *Boston Globe*.

"I wanted to publish a magazine for the sailor interested in learning how to navigate in storms and what to do if his kid fell overboard," Mr. Goldhirsh told her. "Who cares if Mr. Vanderbilt rafts up with Mr. Morgan."

In eight years Mr. Goldhirsh parlayed that success into two more boating related magazines, *Motorboat* for "stink-pot" owners and *Marine Business* for the boatbuilders and marina operators who service both. His United Marine Publishing Co. is a $12 million success story.

Now the biggest gamble yet is about to come out of the company's modest, comfortable, and free-wheeling quarters on Commercial Wharf: a new magazine, called *Inc.*, for what most people think of as "small business." By that Mr. Goldhirsh means companies doing between $1 and $25 million in annual sales — growing companies where the people in charge have to be expert in everything from technology to pension funds, equipment, and insurance.

"Big companies have experts in each of these areas," Mr. Goldhirsh told Ms. Trausch, "and these specialists get magazines covering their specialties. The small business manager doesn't have time to read all those magazines. He needs a publication that will cut through that information for him and put it in one place."

Inc. will go to 400,000 managers of 100,000 companies starting in April. After only three weeks of selling, *Inc.* had commitments for 30 pages of advertising. That seems to add substance to Mr. Goldhirsh's idea that there is a "new wave" of interest in the needs of small business — just at the time when it's being "strangled" by all kinds of government paperwork, high interest rates, and economic uncertainty.

working on water skiing. Andrew, age 4, is swimming fairly well. (As you can see this letter was written last summer.) Thomas is employed by Alliance Capital Management in N.Y. as an investment analyst — usually for technology companies.

Now for some really old news articles and releases. **Dennis Buss** was honored by Texas Instruments as one of its leaders in science and technology. The plaque which T.I. awarded to Dennis describes him as Texas Instruments' leading technical innovator in several research areas. These include charge coupled devices. Dennis has been granted 13 patents for his outstanding work. . . . Raytheon announced that **David Wilson** has just been granted a patent for a radiographic camera with a focusing element that provides a clearer image of radioactive medicines injected into the body for X-ray and gamma ray diagnosis. David has been with Raytheon since graduation in 1963. In 1977 he was designated a senior research scientist at Raytheon. The Wilsons continue to live in Billerica, Mass., with their two sons James, 14, and Paul, 11. **Louis Thompson** was sworn in last May as Director of the Northeast Corridor Improvement Project. Thompson served at D.O.T. as a transportation budget and policy planning analyst in 1968-1973. He is returning to government after five years as a senior analyst with the Washington, D.C., consulting firm of Richard J. Barber, Associated, Inc.

Dave Stickler has been appointed as Chairman of the Aerophysics Research Committee at Avco Everett Research Laboratory. Dave has been an active member of the staff since 1973, and has worked in the areas of coal combustion and coal processing. . . . **Allan Tobin** is conducting birth defects research at U.C.L.A., under a March of Dimes Grant. Allan, an assistant professor of biology, is investigating a theory that some inherited disorders result from a flaw in the way a gene's instructions are transmitted to surrounding parts of its home cell, rather than from a missing or abnormal gene in the usual sense. Such a flaw is thought to cause thalassemia, an eventually fatal form of anemia which primarily affects people of Italian and Greek descent. Allan hopes to shed some light on how a normal gene may become involved in genetic disease through betrayal by other factors in the human cell. Elaine, Allan's wife, is also an assistant professor of biology at U.C.L.A. The Tobins live in Los Angeles with their two sons, David and Adam.

End of column — let's have some real letters, folks, or, at the very least, Alumni Fund envelope flaps. — **Mike Bertin**, Secretary, 18022 Gillman St., Irvine, Calif. 92715

64

Greetings, Classmates. Business has picked up this month, so we are saved from a severe case of no-class-news disease.

Don J. Silversmith writes that he is in charge of photolithographic mask-making and silicon MOS and CCD integrated circuit fabrication at M.I.T. Lincoln Laboratory. Don and Linda live in the Chestnut Hill section of Brookline with their two sons, Jolyon (6) and Galen (2). On a trip to Palo Alto last May, Don visited **George Irwin**, who is currently on the staff of Stanford Linear Accelerator. **Philip Dangel** visited in July; Phil did his M.I.T. work in Course III (B.S. in '64 and Ph.D. in '70), received an O.D. from New England College of Optometry in 1976, and has a practice in El Paso, Texas. Thanks for all the news, Don.

Received an "alumni-gram" from **Bruce W. Stevens**, who is currently employed as a senior environmental engineer for Rohm and Haas Company. Bruce is heavily involved in outside activities as well — he's a Division Lieutenant Governor of the Toastmasters and a Vice President of the M.I.T. Club of Delaware Valley. . . . Also received a nice newsgram on **Klaus Kubierschky**. Klaus, the retiring President of the M.I.T. Club of Boston, was presented a Certificate of Appreciation for his "dedicated services" and "leadership."

The Institute has recently made three visiting

appointments to the School of Science, and one was to a classmate of ours. **Lance F. Bosart**, on sabbatical leave from the faculty at State University of New York at Albany, has been appointed visiting associate professor in the Department of Meteorology for ten months effective October 1. During his time here Professor Bosart will be working on a study to more accurately predict amounts of rainfall.

That's all for this month, people. Let's have some enthusiasm and some letters and some contributions. This is a Class Reunion year — the Fifteenth — so write! Shalom. — **Steve Schlosser**, Secretary, 11129 Deborah Drive, Potomac, Md., 20854

65

Two Class Heroes this month, giving your old secretary a holiday present. **Chuck Seniawski** is just completing a one-year tour of duty as Chief of Logistics at Johnson Atoll, "four specks in the Pacific some 700 miles southwest of Hawaii." The isolation was compensated for by a low fall temperature of 76°. In March Chuck rejoins Sue and the children at his new post at Malstrom Air Force Base in Great Falls, Mont. . . . Lynne and **Jesse Lipcon** passed on the word about a new addition to their family: Scott Johnson was born October 30, weighing in at 6 lbs. 5 oz. . . . **David Rubin** is now senior planner for COMSIS Corp., a transportation consulting firm doing research for federal agencies. Dave, Sharon and the children just spent three weeks touring Europe. . . . **Richard Armstrong** has been elected Secretary of the M.I.T. Club of Boston. . . . **John Golden** has been appointed manager, information systems, at Compugraphic Corp. in Wilmington, Mass. Finally, a sharp-eyed reader found 65er **Efraim Arazi** as the thinking man's Dewar's Profile; he was featured in a two-page spread advertising *Scientific American*. As well as skiing and racing motorcycles, Efraim founded SCI-TEX, a leader in the field of computer processing of color images.

Over Thanksgiving we met a cat that would "fetch" a small wad of paper — I did not think cats ever deigned to do such dog-like things, but it has opened up new horizons for our two felines. We have many boring cat stories waiting to be told — so send more news. — **Edward P. Hoffer**, M.D., Secretary, 12 Upland Rd., Wellesley, Mass. 02181

66

Dear Class of '66, I continue to receive notices of **Fritz Schaefer**'s A.C.S. Award in pure chemistry for his achievements in quantum chemistry. Fritz, there seems to be a lot of people who want to remind the class that you are $2,000 richer now. Once again, congratulations.

The Department of the Interior sent an eight-by-ten portrait of **Robert Wesson** to tell us that he has been named chief of the Office of Earthquake Studies at the U.S. Geological Survey National Center, Reston, Va. In his new post, he will direct a staff of more than 400 scientists and technicians involved in a $31 million research program conducted by the U.S.G.C. as part of the National Earthquake Hazard Reduction Program.

Dave Vanderscoff writes that, "contrary to popular belief, I have found Bismark, North Dakota, where I recently became president of Northern National Life Insurance Co., to be quite comfortable and lovely. The sky is generally crystal clear and deep blue, which makes those 40 below zero days in the winter seem much warmer." Dave, now that you are in North Dakota, you are all set to rise up in the footsteps of **Chuck Boley**'s father who ascended one of those 1,000-foot North Dakota radio towers in an open elevator!

Carson Eoyang, one of my fellow Course VIs, added a new family member on July 5, 1978, named Mason Tsao. . . . **Stuart Vidockler** was promoted last summer to budget director of Houghton Mifflin where his responsibilities include forecasting and some financial systems development. Houghton Mifflin publishes texts in the basic sciences. I hope that if any of you want to publish a book, you will support Stu in promoting the influence of M.I.T. and of the class of '66 by calling him (617-725-5000) and publishing through Houghton Mifflin. . . . **James E. Kester** is an Air Force major with the Military Airlift Command at Zweibrucken, Germany. He recently received his second Meritorious Service Medal for his outstanding duty performance as a computer systems analyst at Offutt A.F.B., Nebraska.

The last item is next and it is an anonymous contribution from a member of the class of '72 and my very first personal postcard as class secretary. Whoever you are, I thank you for keeping watch over our classmates. If any other readers have a minute to pass on information about the class of '66, please do so. I and many other readers will thank you. . . . **Richard Kusper** lives in sunny Orange County where he greatly enjoys the warm weather that he got so used to living in the South Pacific so many years. He has just purchased a house which means that he'll have to take some time off from restoring Corvettes to get himself settled into the swimming pool and hot tub. He works for MacDonald/Douglas in the radar group.

Keep up the good work and promotions, '66. Your progress is the class' progress. — **Joe Patterson**, Secretary, 1403 Gerard St., Rockville, Md. 20850

67

Edie and **Chuck Hottinger** have their first Colorado baby, their third daughter, Sarah Ann, born December 4, 1978 . . . . **Bill Lange**, who recently became director of schedules for Pan American World Airways, is in charge of the operational design of worldwide schedules. He and his family have moved to Wilton, Conn. — **Jim Swanson**, Secretary, 669 Glen Rd. Danville, Calif. 94526

70

At the time of the publication of this issue, classmates should have just enough time to talk to **Michael Prager** about hunting wild mushrooms this Spring. He would like classmates to call. . . . **Arthur Perkins** was recently promoted to administrative assistant to the vice president of chemical manufacturing and engineering at Air Products and Chemicals, Inc. This all occurred at approximately the same time he married Gerri Coyle of Philadelphia. . . . **Wendell Brase** has been very busy. After leaving the staff of the president at J.C. Penney, he went to the University of Rochester, Eastman School of Music, and is now managing fiscal resources and renovation. Since 1977 he has been associate director for administration for the Laboratory for Laser Energetics setting up management systems. Recently he was named chief financial officer for University of California, Santa Cruz.

The Vegelers are watching over the construction of their new house and are putting the finishing touches on the interior. In between that I am slowly constructing an oak grandfather clock which shall find a place in my office along with my other oak antiques. Sean is hoping that spring will come so he can play in his sandbox. — **Robert Vegeler**, Secretary, Kennerk, Dumas, Burke and Backs, 2120 Ft. Wayne National Bank Bldg., Ft. Wayne, Ind. 46802

71

Congratulations to Mike and Vicki Oakes on the birth of their third child: a boy. Chaplain (Captain) **Edward T. Brogan** is a part of "Crested Cap '73" a N.A.T.O. exercise conducted in Germany. He is assigned to the 4th Tactical Fighter Wing at Seymour Johnson A.F.B. in N.C. The exercise is aimed at enhancing our ability to rapidly reinforce N.A.T.O. . . . **William H. Lee** is president of the M.I.T. Club of Boston. . . . **Barry Zevin** was promoted to assistant professor of architecture at M.I.T. . . . **Neal R. Satten** sends the following Milestones: Married Rona Cordish 1973; M.D. Harvard Med '75; Internship Mass. General 75-76; Psychiatry Residency 1976-79 at a Pennsylvania Hospital.

David M. Hegedus writes: "I am currently in an interdepartmental Ph.D. program with the organization studies group of the Sloan School and the division for study and research in education at M.I.T. and am working on my thesis. Looking forward to a degree in the summer of 79 as is my wife Susan." . . . Everyone must be skiing . . . few letters to the mailbox mean very little news. Please write. — **Hal Moorman**, Secretary, P.O. Box 1808, Brenham, Tex. 77833

72

Paul Hooper has just completed Air Force fighter lead-in training at Holloman A.F.B. in New Mexico. . . . **Matthew Bloom** was married to Deborah Preiss in October 1977 and is practicing dentistry in Manhattan. . . . Bob and Kathy Dwyer have a son Timothy, born last March. Bob is working on a doctorate at U.R.I. and is chairman of the Coventry, Rhode Island Conservation Commission. . . . **Bill Ku** is now an astrophysics professor at Columbia and teaching the equivalent of 8.01. . . . **Dominic Ho**, who is at Harvard Medical School and **Victor Tom** and **Don Levinstone**, still graduate students at the Institute were recently observed dining in Chinatown. — **Dick Fletcher**, Secretary, 135 West St., Braintree, Mass. 02184

73

Hoping you all had Merry Christmases and Happy New Years, we move along into a mound of mail piled upon my doorstep. **Mike Wargo** received the Hugh Hampton Young Prize from M.I.T.; a $3,000 award given to a student for outstanding work in coordinating multidisciplinary projects. . . . Lieutenant **Trip Barber** is still active in the United States Navy (". . we sail the ocean blue . .") working on a master of science in electrical engineering at Naval Postgraduate School in Monterey, Calif. Trip was in Bulgaria recently, flying model rockets for the United States team (oh, yes, Doctor, there really *is* one!), of which seven of twelve members are ex-Beavers. He notes that **Martin Romeo** just arrived there for the same program. He also rapturously *adores* this column (slight license, there). . . . **Larry Isaacs** has graduated from the U.S.A.F. med service officers' orientation course at Sheppard Air Force Base, Tex. Larry is now assigned to Dyess Air Force Base, Tex., as a dentist with a Strategic Air Command unit.

Debra Judelson received an M.D. from Harvard in the H.S.T. program, then moved to San Francisco for nice weather and an internal residency (think about that . . .). She is currently chief medical resident at Kaiser Hospital there, learning about health maintenance organizations. In July, she starts work under a fellowship in cardiology in Los Angeles. . . . **J. Peter Buchanan** is now working for the Ontario Ministry of the Treasury as an economist and living in Toronto. **Jack Levy**, on the other hand, is not. He has been named director of financial planning for the Beacon Companies, a huge firm which manages real estate.

Roger Bowers received an M.D. from S.U.N.Y. at Buffalo (Aside — obviously not in meteorology!) in 1978, and became a resident in radiology at University Hospital in Ann Arbor. Roger married Denise Lyon in August of 1976; a child, Leslie Ann, was born on May 11, 1978. . . . **John Wall** finished his Sc.D. thesis in course II, and works for Stanford Research Co. in Sausalito, Calif. Work, he says, is fine, but the trout fishing is better. . . . **Martin Rosenberg** was named Mellon Teaching Fellow at Carleton College in Minnesota. He has taught previously at La Salle and the Universities of Delaware and Pennsylvania. . . . **Tony Scandora** was in the news in Chicago, where he performed the world's first successful appendix transplant. He announced plans to

follow this advance by attempting to graft freckles.

I want to thank those of you who have written, and especially those of you who said how much you enjoy the column. If there's a reason why you never fail to see some '73 news here, it's the special feeling I get when an otherwise bland and newsless letter perks up at the end with a side message of appreciation. May the Bird of Paradise pour Quik in your milk daily. Na-noo. — **Robert M.O. Sutton**, Secretary, 37 Fairbanks St., Brighton, Mass. 02135

74

I apologize for not having a class notes column for several months. There has been a mix-up with the U.S. mail and home addresses which have all been hopefully straightened out. (When in doubt, blame the U.S. mail — or telephone company.) Now, some much overdue news.

Bill Hickling graduated from Cornell Medical College last May and has begun his residency in pediatrics at Dallas Children's Medical Center. Bill is married to a registered nurse who graduated from Cornell's Nursing School. . . . **Lawrence Rubin** is married and bought a house in the Hollywood Hills. Lawrence is working for Hughes Aircraft on signal processing.

John Pearson is presently employed as the staff engineer for the Maintenance Dept. at Commonwealth Edison's Quad-City Nuclear Power Plant. John is also the proud father of a 5-month baby girl, named Melissa Anne. . . . **Elizabeth Wise** and husband **Robert** (jock) **Young** are living in San Diego where Elizabeth is pursuing a family practice residency and Jock is learning to surf. Last summer, **Stephen Wolfe** completed a 9-week bicycle tour across Canada and is contemplating one around the world next summer (but what will he do for the summer after?).

John Norvik received a Ph.D. in Operations Research from the University of California at Berkeley. . . . **Stephen Jordan** graduated Harvard Business School and is a Production Planning Manager at Mostek Corp. in Dallas, Texas. . . . **Pete Travis** finished his third year of medical school at Downstate Medical Center in Brooklyn, N.Y., and got married to Lynne Focis, a nurse working for the Town of Hempstead. **Jack Daiss** and **Rich Shepherd** were ushers.

Ted Kochanski is at the University of Texas in Austin expecting a Ph.D. in Physics in June of 1979. Ted says the summers there are extremely different from those up north. He also enclosed a postcard from **Richard Webb** in the Himalayas where he made a solo attempt at climbing a 20,300-ft. mountain. Richard continues, "Got snowed on and headache and nausea from altitude but continued on in morning to 19,000 ft. where route went across a short, steep snowfield ending in vertical drop — certain death if I slipped or lost a crampon. Sat there for a half hour, estimated probability of death at 50 per cent for a man who wasn't roped in, took a few steps across then turned around and headed back down. . . . now to continue my trip around the world."

William Klein has been promoted to Major of the U.S. Air Force. . . . **Charles Bruno** quit his job and in return received a large promotion and raise to stay. . . . **Bill Blanford** is an electrical engineer for Tektronix and goes hiking with his wife and two children in the Northwest. . . . **Alan Horowitz** graduated from Columbia Law School, is an associate in the law firm of Covington and Burling in Washington, D.C. and is married to Ms. Sharon Schwartz.

Richard Alan Hartman writes: "I graduated from the University of Missouri-Columbia School of Medicine. . . . will be starting a residency in obstetrics/gynecology at the Jewish Hospital in St. Louis . . . expecting an addition to the family in late November."

Naomi Markovitz writes, "My second year teaching at the joint school of the religious kibutzim (collective agricultural settlements) in the Beit Shan Valley is drawing to an end. I have been teaching arithmetic, geometry, algebra and trigonometry — all in Hebrew — in almost all of the 12 grades encompassed in one school. I have also spent 15 minutes a week teaching introductory conversational English to third graders."

Charles E. Calhoun III writes: "Have finally graduated from Wharton School of the University of Pennsylvania with a master's in Business Administration. Joined Philadelphia Engineering and Consulting firm of Day and Zimmerman, Inc. as project coordinator in Real Estate Services Division and Corporate Development."

Hoping your news is good news — **Dennis Dickstein**, 17 Forest St., #21, Cambridge, Mass. 02140

75

Sorry I missed last issue, but I must say that my mailman did not break his back bringing me letters from the class of '75. But we're doing better this month with one fund envelope, a couple of news clippings, and other assorted items.

Jim Sandman is currently working for Xerox in Palo Alto, Calif. and says he's enjoying working and living in the Bay area. . . . **Vaiva R. Vebra** taught Elementary Lithuanian and Lithuanian History and Culture this fall at Sacred Heart University. She is presently a doctoral candidate in ecology on a university fellowship at Yale. . . . **Charles L. Tucker III** has been appointed assistant professor of mechanical and industrial engineering at the University of Illinois at Urbana-Champaign. He expects to receive his doctorate this year.

Well, the class Evil Knievel Award undoubtedly goes to **Steve Streifer** who managed to be mowed down by a St. Johnsbury semi while riding a Honda 450 — and survive to tell the story! That durable guy got away with a cut in one foot, one destroyed boot, a fractured wrist, and four days accommodations in Cambridge City Hospital. If his lawyer is shrewd, his settlement might help put him through Harvard Business School, which he is presently attending.

When **Anita Horton**, **Jim Moody** and I were together at the Alumni Officers Conference this year, we realized that our fifth year class reunion is not far in the future. Although no formal planning has taken place as yet, I urge all of you with ideas on this matter to keep them in mind, dream some more up, and get in touch with me or the Alumni Association when you can. When the planning ball really starts rolling, I'll try to keep you all informed, especially those of you who may be willing to volunteer your services in some capacity. That's all for now. — **Jennifer Gordon**, Secretary, 22 Centre St., Cambridge, Mass. 02139

76

Some old news, some new news, and all of it, good news.

Jeff Baerman, at the time of his note, was studying cardiac surgery, and reports that "all is going smoothly." In the same letter he sends news of another classmate. Lynn and **Courtney McCracken** had a 10 lb. 5 oz. baby boy on September 26, 1978. His name is Ryan Patrick McCracken.

Jim Shewbridge left his job with Exxon Nuclear Co. and returned to the Tute for an Sc.D. in metallurgy last fall. . . . **Gary Tyler** has taken a field engineering job with General Electric's Installation and Service Engineering Division. Training will be in Schnectady, N.Y. for possible eventual assignment anywhere in the world. Gary is currently a member of he Institute of Electrical and Electronic Engineers and the Association of Iron and Steel Engineers.

Your secretary saw both **Mike Rabkin** and Gary Kaitz, '77, when they were in Boston visiting. Both are fine and doing well. Mike at Duke Medical, and Gary at Jack Faucette Associates, a consulting firm specializing in urban ills.

I also had occasion to speak with **Mike Steckler**, who is at the Lamont School of Oceanography at Columbia University. Mike had just passed his doctoral orals, and his first paper has been published by *Earth and Planetary Science Letters*. Congratulations.

Sharon Zito has written an interesting letter, ". . . finishing my master's degree in animal science at the University of California in Davis. My field of interest is reproductive physiology. Many of my friends from my living group have also moved out to California: Steve McDonald, '74, is working on his Ph.D. in physics at Berkeley; John Stiehler, '74, who married a girlfriend of mine is at business school at Stanford; **Mitch Lazar** is at medical school at Stanford; and Al Czerwinski,'75, is working in a lab at Stanford. We are thinking of calling ourselves Burton 5 West. . . . Life at Davis is very relaxed and easy going for me . . . the course work is very interesting and certainly not overwhelming (like I found at M.I.T.) However, I do miss the social life M.I.T. had: the 6 : 1 ratio of men to women was appealing in some ways for the female students! Out here, there are too many blond-haired, beautiful (typical Californian) women and not enough intelligent and good looking men. But I am basically happy living in the country and working with animals."

My apologies for this issue's brevity. However, the pressure and effort involved in keeping a small business going leaves scant time to devote to the gathering of class news. So, please keep the letters coming, and accept my apologies for my failure to reply to them personally. — **Arthur J. Carp**, Secretary, Endymion Commodities, Inc., 131 State St., Suite 616, Boston, Mass. 02109

78

Everybody's in California, it seems. **Geoff Baskir**, creator of "Stickles," writes from his new home in Stanford, Calif. Geoff says that he is in the Infrastructure Planning Group of the Stanford Engineering Department and is once again busy in school politics, having been elected to the Senate of the Associated Students of Stanford University. His efforts to get a west coast version of Stickles published have failed ("too technical for Stanford" said the editor) so he's been donating his creative efforts to the school humor magazine. Geoff reports "hoardes" of '78s out there at Stanford, including **Rich Zingarelli**, **Nino Pedrelli** and **John Little** with **Robin Newmark** at nearby Santa Cruz.

Jean Gregory also writes from Stanford; she's in the material science department, living in Crothers Memorial Hall, which she claims to be their answer to Ashdown house. She too has spotted a bunch of classmates in sunny central California. To name a few: **Dave Medeiros**, **Dave Stuart**, **Paul Limburg** and **Carolyn Cook**.

Yet another letter from a classmate out on the west coast — **Josie Stein** is at the University of California at Berkeley in mechanical engineering and is splitting an appartment with **Jerry Epstein** (physics at Berkeley) and **Willie Rifkin** (working in Oakland). It will come as a surprise to almost no one that she reports that Berkeley is overrun with M.I.T. '78s too. Among them are **Dan Amidei**, **John Stahr**, **Neil Soiffer** and **Jordin Kare**. I can think of a couple of others; **Rich Perlstein** is studying for his M. Arch. after months of equivocation. **Jennifer Jonas** and **Sue Hanson**, both of Baker, are also in grad school at U.C.B.

Sue Coppersmith writes from Cambridge, England, "I am enrolled in a course with no exams or assignments until June and it doesn't matter whether I pass or fail, so I haven't found the academic pressure overwhelming." The crowning touch is "the lady who comes in each morning to clean my room and make my bed. Life is tough." Other than her rigorous academic schedule, she's playing volleyball, trying out for crew, and teaching the English the wonders of chocolate brownies.

Alan Schwabacher has recently joined the staff of the General Electric R&D Center in Schenectady, N.Y. Al will be working as a chemist in the Polymer Properties and Reactions Branch.

Rain, sleet, snow and final exams won't stop me from writing, but lack of news will. So keep those cards and letters coming — **David S. Browne**, Secretary, 551 South State St., Ann Arbor, Mich. 48109

Courses

I
Civil Engineering

The secretary of the M.I.T. Club in Mexico, **Jorge Diaz-Padilla,** Ph.D. '74, has been elected to the Mexican Academy of Engineering. He is a partner and technical director of Felipe Ochoa and Associates, Consultants. . . . **Avinash Singhal,** Sc.D. '61, recently joined the civil engineering faculty at Arizona State University. . . . **Joseph F. Whittle, Jr.,** S.M. '74, writes that he is now a registered professional engineer in Florida and working as a geotechnical engineer with Law Engineering Testing Co. in Tampa. . . . **Douglas H. Merkle,** Ph.D. '71, writes, "I'm the deputy program manager for the Air Force Weapons Laboratory's TRESTLE Program at Kirtland A.F.B. in New Mexico. TRESTLE is an aircraft electromagnetic pulse simulator."

Thomas S. Maddock, S.M. '51, presented a paper entitled "Cross Valley Canal — A Case Study of Project Implementation by Local Agency Joint Venture" at the A.S.C.E. National Specialty Conference at Virginia Polytechnical Institute last summer. He is currently serving as vice president of the Los Angeles section of A.S.C.E. He also reports that Boyle Engineering Corp. has established an operation office in West Germany. . . . **Philip La-Fan Liu,** Ph.D. '74, was awarded a Walter L. Huber Civil Engineering Research Prize from the American Society of Civil Engineers last October. He received the prize for "his research on wave hydromechanics and its related engineering problems including coastal currents and shoreline processes; on the development of procedures and computer programs for nonlinear free surface flow problems in ground water and water waves." Dr. Liu is assistant professor of Civil and Environmental Engineering at Cornell University. . . . **Cranston R. "Chan" Rogers,** S.M. '51, is manager of the newly established Boston office of Black and Veatch, the consulting firm. Mr. Rogers has spent all his professional career in Boston, most recently with Maguire, Inc., where he was responsible for directing the design of such projects at Interstates 93 and 95, and the tunnel section of the J. F. Fitzgerald Expressway.

II
Mechanical Engineering

Chester L. Nachtigal, Ph.D. '69, has joined the Weyarhaeuser Co. in Faconia, Wash., where he is involved with computer automation of lumber manufacturing. He has been associated with the School of Mechanical Engineering at Purdue University for the past nine years. . . . **Leonard E. Smollen,** M.E. '62, is the coauthor of two books that were published in 1977: *New Venture Creation: A Guide to Small Business Development,* Richard D. Irwin, Inc., and *Sourceguide for Borrowing Capital,* Capital Publishing Corp.

Thomas C. Zebehazy, S.M. '72, has risen in the ranks at Chevrolet Engineering Center, and is now a project engineer responsible for forecasting the fuel economy of future passenger cars. . . . **Aldo Crugnola,** Sc.D. '72, dean of the College of Engineering at the University of Lowell, has been appointed to the executive committee of the Society of Plastics Engineers.

III
Materials Science

The Northeast Solar Energy Center announces the appointment of **Seymour L. Blum,** Sc.D. '54, as vice president and director of program development. "He brings a considerable background and reputation in energy and resource management," says President Lawrence Levy. Dr. Blum comes most recently from MITRE; before joining MITRE he was vice president of the Illinois Institute of Technology Research Institute. He also serves as a consultant to the U.S. Congress and on many committees, among them the visiting committee of this department. . . . **Frank F. Aplan,** Sc.D. '57, is the 1978 recipient of the Robert H. Richards Award of the American Institute of Mining, Metallurgical and Petroleum Engineers. It's the highest award given in the profession.

Stanley I. Warshaw, Sc.D. '61, completed the Harvard Advanced Management Program in December. Now back in Washington he is director of product technology in the National Bureau of Standards. . . . **Barry B. Holmes,** Ph.D. '69, joined Volkswagen of America in October last year. He now has been promoted to director of the Central Laboratories.

IV
Architecture

Barbara Putnam, M.Ar. '77, is the project manager and designer for one of Total Environmental Action's latest undertakings: the design of a "zero" energy house. "We want the house to be so well-insulated that it can heat *itself* by using the sun coming through windows, excess heat from appliances, the heat from lights and people, and so on," says Ms. Putnam. The project is carried out under a contract from the American Institute of Architects Research Corp. . . . **Steven L. Lerner,** M.Ar. '71, was awarded the First Award of Excellence by the Rhode Island Chapter of the A.I.A. last summer for the design of a dormitory at Brown University. Part of the jury's commments reads, "The way in which the building was needle-threaded to accommodate the existing buildings and garden showed a degree of excellence."

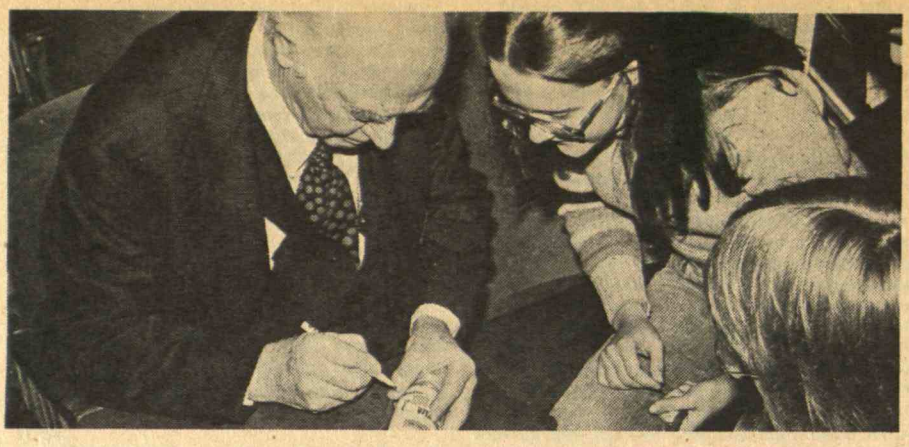
J. Walter Roth, M.Ar. '52, was recently appointed director of art-in-architecture and historic preservation for the U.S. Public Buildings Service.

Mining and Minerals Research

M.I.T. is the home of one of 20 research institutes in mining and mineral resources now being funded throughout the U.S. by the Office of Surface Mining of the Department of the Interior. The goal is to strengthen interdisciplinary teaching and research in mineral resources engineering and management, and the program is expected to grow as the institutes organize to fulfill this mission.

John F. Elliott, Sc.D. '49, Professor of Metallurgy, heads the new institute at M.I.T., and he says its seed funds — initially $110,000 a year, with an additional $50,000 a year for scholarships and fellowships — will be used for new undergraduate teaching programs and for strengthening the existing graduate program in mineral resources engineering and management. There will be a consortium of Massachusetts colleges and universitites to advise and share in the project.

Of 20 research institutes established by the Office of Surface Mining, M.I.T.'s is the only one at a private institution.



As he introduced Linus Pauling for the Karl Taylor Compton Lecture, Robert A. Alberty, Dean of the M.I.T. School of Science, suggested that perhaps some of the many students in the overflow audience had brought vitamin C bottles to be autographed by Dr. Pauling. There was one, at least, and Dr. Pauling cheerfully obliged. (Photo: Calvin Campbell)

Chemistry's Past and Present, and the Future of "Everything that Is Interesting"

After receiving his master's degree in organic chemistry from M.I.T. in 1887, Arthur A. Noyes went off to Europe to study with the German scientist Wilhelm Ostwald, who had just begun lecturing on the then-new field of physical chemistry. With his doctorate (1890) and first-hand observation of German progress in physical chemistry, Dr. Noyes came home convinced of the need to establish the discipline in this country. He did just that at M.I.T. in 1903, and the Department of Chemistry celebrated the 75th anniversary of his accomplishment in a special program last fall.

Dr. Noyes was "remarkable in looking toward the future," Nobel laureate Linus Pauling told the gathering. Through September of last year, 440 students had earned doctorates in the Research Laboratory of Physical Chemistry which Dr. Noyes set up (with the help of a sizeable contribution from his own pocket). Among the graduates have been leading American physical chemists of their time; so the 75th anniversary event was an occasion to review some science history and think about present trends and future opportunities.

Looking ahead, John M. Deutch, Ph.D. '65, director of research for the U.S. Department of Energy, summarized the host of basic technological objectives of his agency; in all areas — energy conservation and storage, coal use, nuclear energy, environmental concerns, biomass energy — he found a "close relationship" between physical chemistry and pressing energy problems.

Right now, said Dr. Edward R. Kane, Ph.D. '43, President of E. I. du Pont de Nemours and Co., the U.S. climate for research and development must be improved for the sake of "the scientific, technological, and economic strength of this country."

What is physical chemistry today? The jovial answer, "It is everything that is interesting," came from John Ross, Ph.D. '51, Frederick G. Keyes Professor of Chemistry at M.I.T., who described "trends in a lively science" and its "impressive progress."

Whereas the first three Ph.D. degrees awarded by M.I.T. came from Dr. Noyes' laboratory, Dr. Pauling recalled that he himself was only the seventh Ph.D. candidate at the California Institute of Technology when he met Dr. Noyes there. Dr. Pauling, now President of the Linus Pauling Institute of Science and Medicine, was introduced for his Karl Taylor Compton Lecture by one of his former students, Robert A. Alberty, Dean of the M.I.T. School of Science.

Chemical Abstracts, a fundamental tool of modern science, is an outgrowth of the review of chemical literature started by Dr. Noyes, said Dr. Pauling. And it was Dr. Noyes who urged Dr. Pauling to investigate x-ray crystallography and the nature of chemical bonds, the areas in which he made significant contributions.

V
Chemistry

R. Bruce Frye, Ph.D. '76, writes that he now is a product development chemist at General Electric Silicone Products. . . . **Frank W. Dobbs,** Ph.D. '61, has been appointed dean of the College of Arts and Sciences at the Northeastern Illinois University. . . . **Phyllis Magat,** Ph.D. '47, leaves Delaware to assume the position of superintendent of schools in Springfield, Vt.

David W. Ellis, Ph.D. '62, whose term as president of Lafayette College began last August, was officially inaugurated in a ceremony that took place on October 20. Dr. Ellis is the third generation of college presidents — his father, Dr. Calvert Ellis, was one of the speakers at the inaugural luncheon. . . . **John T. Yates,** Ph.D. '60, recently received the Samuel Wesley Stratton Award from the National Bureau of Standards. One of his major areas of research at N.B.S. is the application of modern measurements to the chemistry of catalysts which has led to a better understanding of nickel catalysts in the coal gasification process.

VI
Electrical Engineering and Computer Science

Christopher A. Laspina, S.M. '57, joined Pitney Bowes last fall as manager of design and development for the company's advanced mailing systems. . . . News from **Louis Weinberg,** Sc.D. '51: "I am deep in work on matroids. I lectured for three weeks at the Technical University of Denmark on matroids. After that I won a research fellowship from the Japan Society for Promotion of Science to spend three months researching in Japan. I hope to do this on my sabbatical next year — it would be nice to spend six months of my sabbatical at M.I.T." Dr. Weinberg has also had time to write three articles for the *Encyclopedia Americana* on "Black Box," "Network Theory," and "Operations Research." . . . **John Makhoul,** Ph.D. '70, visited the Soviet Union last summer as part of an exchange program in the area of natural language processing.

The National Bureau of Standards selected **Roy G. Saltman,** S.M. '55, to receive the 1978 E. U. Condon Award. It was his report on copyright in computer-readable works that won him the recognition. . . . **Edward E. David, Jr.,** Sc.D. '47, president of Exxon Research and Engineering Co. and former science advisor to the president of the United States, has been appointed to the Rockefeller University Council. . . . **George W. Swenson,** S.M. '48, has been appointed to head the Department of Electrical Engineering at the University of Illinois at Urbana-Champaign. He is a professor of both electrical engineering and astronomy and was acting head of the astronomy department at the university from 1970 to 1972. Among his many significant contributions in the field is the pioneering work in the use of earth satellites for research on the ionosphere.

VI–A
Cooperative Program in Electrical Engineering and Computer Science

The VI–A office continues to have many vistors. Alumni who have stopped by recently include **Scott A. Keneman,** '66 (R.C.A. Labs), who is presently a senior member of the Engineering Staff of R.C.A.'s New Products Laboratory in Indianapolis; **W. Gordon Bowie,** '29 (N.Y. Telephone and Bell), who has now retired from the New York Telephone Co.; **H. DuBose Montgomery,** '71 (Bell Labs), who is associated with the management firm of Kirk, Knight and Co. based in Menlo Park, Calif. (DuBose is currently president of M.I.T.'s Alumni Club of Northern California); **Thomas H. Crystal,** '59 (Bell Labs), who is with the Institute for Defense Analyses in Princeton, N.J.; **Albert J. Carey,** '28 (Bell System), who is enjoying his retirement; and **Gary K. Montress,** '69 (Raytheon Co.), who is enjoying his work at the United Technologies Research Center in East Hartford, Conn. (he came by with his wife, Sally).

To the many who have inquired after me, concerning my heart attack on September 23, I am happy to report that I am recovering well and as of December 4, returned to work on essentially a full-time basis. I greatly appreciate the many notes of sympathy and encouragement I received during my hospitalization from so many VI–A alumni and company friends. Thanks!

This "VI–A Newsletter" has received much favorable response. VI–A alumni who happen to be in the Boston area are encouraged to come by and say hello. If not, then drop us a note and let us know what you are doing. — **John A. Tucker,** Director, VI–A Program, Room 38–473, M.I.T., Cambridge, Mass. 02139

X
Chemical Engineering

Donald W. Peaceman, Sc.D. '51, writes: "Have been employed since graduation at Humble and Exxon Production Research in Houston. I recently had a book published by Elsevier, entitled *Fundamentals of Numerical Reservoir Simulation.*" . . . **Frank R. Graziano,** S.M. '77, has been with Proctor and Gamble in Cincinnati since March, 1977. He started in manufacturing management and is now energy coordinator of the Ivorydale Soap Plant. . . . **Robert C. Lutton,** S.M. '52, is a patent development engineer with Phillips Petroleum. He joined the company last fall.

James S. Law, S.M. '72, has moved to Florida, and is now a licensed professional engineer there. . . . We have received the following note of appeal from **William S. Hutchinson,** S.M. '49: "This will be my third year working for the Alumni Fund drive. I do not understand why I do not persuade more military alumni to contribute. As a professional infantryman I applied for M.I.T. first, was proud to be selected, and benefited greatly from the experience. I remind my colleagues of this without success. What am I doing wrong?"

XI
Urban Studies and Planning

Lawrence Goldblatt, M.A.A. '75, has moved to Kansas City and opened a practice there. He writes that he missed Boston at first, but now enjoys the "pleasant, quite, easygoing air to Kansas City." His firm is growing and the area is full of opportunities especially in the field of architectural production and estimating. Lawrence Goldblatt Planning and Development provided the financial and development analysis for a project to save a complex of older buildings in the heart of Kansas City. Another project led them to design an internship program for architectural and planning students. . . . **David H. Howells,** S.M. '55, professor emeritus at North Carolina State University and the University of North Carolina at Chapel Hill was recently honored with the governor's Conservation Award.

Robert M. Hollister, Ph.D. '71, a member of the faculty since 1971, has been promoted to associate professor.

XII
Earth and Planetary Sciences

Nathan Hawley, Ph.D. '78, is currently a visiting professor in the Department of Environmental Sciences at the University of Virginia in Charlottesville.

Neil Campbell, Ph.D. '43, one of Canada's most distinguished geologists, died at Sacred Heart Hospital, Spokane, Wash., on July 12, at age 64. A Canadian citizen with resident status in

Planning the Teuber Symposia

To provide a lasting memorial to the late Professor Hans Lukas Teuber, who was Head of the Department of Psychology from its founding in 1964 until his death a year ago, Departmental colleagues are now planning a biennial symposium on topics in neuropsychology. Friends, colleagues, former students, and others who have in some way felt Professor Teuber's influence are accordingly invited to contribute to the Teuber Memorial Fund (Room 4–133, M.I.T.).

"With his keen sense of paradox," write four of his colleagues in the Department, "Professor Teuber loved diversity of ideas and sought out their proponents wherever they were. He promoted scientific exchange by traveling widely and, in turn, attracted many to visit at the Institute. And he was marvelously skilled in communicating his knowledge with enthusiasm and evoking a kindred spirit in those around him."

For all these reasons, the Fund's sponsors think symposia in Professor Teuber's honor are an especially appropriate form of tribute.

Elliot Directing Wallace Observatory

James L. Elliot, '65, who discovered the rings of Uranus — Dean Robert A. Alberty of the School of Science calls them "one of the most striking discoveries in the solar system in the last decade" — while working in the Department of Astronomy at Cornell, came to M.I.T. late last year to be director of the George R. Wallace Astrophysical Observatory and associate professor in the Department of Earth and Planetary Sciences.

Since receiving his Ph.D. from Harvard in 1972, Dr. Elliott has held research positions at the Smithsonian Astrophysical Observatory and at Cornell, where he was named senior research associate in 1974. He holds N.A.S.A.'s 1977 Medal for Exceptional Scientific Achievement.

the United States, his discovery of major mineral deposits in Canada and the United States brought him special recognition as recipient of the Barlow Gold Medal of the Canadian Institute of Mining and Metallurgy in 1947, election to the Royal Society of Canada in 1957, and an honorary LL.D. degree from his alma mater, the University of Alberta, in 1970. He is credited with having discovered mineral deposits that will ultimately yield profits of more than a half-billion dollars.

Ely Mencher, Ph.D. '38, died on December 11, at age 64, after open heart surgery. Immediately after completing his doctoral work Dr. Mencher went to Venezuela where he founded and for a number of years directed the Escuela de Geologia at Universidad Central de Venezuela in Caracas. He returned to M.I.T. in 1952 as associate professor of geology and taught historical and petroleium geology until 1967, when he left to become professor and head of the Department of Geology at the City College of New York, his alma mater. He was specially known for his geological field work in Venezuela and in Maine, where he directed the thesis work of a number of Course XII graduate students in the vicinity of Ashland and Presque Isle. — **Robert R. Schrock,** professor emeritus, M.I.T. Room 54-1026, Cambridge, Mass. 02139

XIV
Economics

Ralph H. Bergmann, Ph.D. '50, is back from Switzerland for the academic year 1978–79; he took a leave of absence from the International Labour Office in Geneva to accept an appointment as visiting professor of Industrial Relations at the State University of New York. . . . **Margaret Garritsen de Vries,** Ph.D. '46, will be included in the next edition of *Who's Who in American Women.* This is in recognition of her 30–year long career as an economist in the International Monetary Fund, her work on several volumes of the history of the fund, and earlier academic honors received at M.I.T. and at the University of Michigan. . . . **James Dana,** Ph.D. '60, has been promoted to full professor at Lawrence University.

XVI
Aeronautics and Astronautics

Henry F. Faery, Jr., S.M. '69, got his Ph.D. in aerospace engineering from V.P.I. last year and is now associate professor in the Department of Mechanics at the U.S. Military Academy in West Point. He is also the recipient of the N.A.S.A.–A.S.E.E. Summer Faculty Research Fellowship.

Ghazala Sadiq, S.M. '78, was a guest speaker at a recent meeting held by the American Association of University Women. She has previously been honored as the first recipient of the Dorothy W. Weeks International Fellowship. . . . A press release from the University of Southern California tells of the death of **George Saunders,** S.M. '63 in the tragic airplane crash over San Diego last September. It was "one of those ironic twists of fate," says the university spokesman. Mr. Saunders was a leading aircraft accident investigator and at the time of his death he was an instructor at the Institute of Safety and Systems Management of the U.S.C.

XVIII
Mathematics

Chung-Wu Ho, Ph.D. '70, has been promoted to full professor at Southern Illinois University at Edwardsville. . . . **Ben Clymer,** S.M. '48, is currently employed at Electronic Associates, West Long Branch as a senior staff analyst. . . . **Robert R. Reitano,** Ph.D. '76, actuarial associate with John Hancock, has been named an associate of the Society of Actuaries. . . . **Ruben Klein,** Ph.D. '74, has put his expertise in mathematics in the

C. J. Coats

service of anthropology and won the Sterling Award for Culture and Personality Studies. Together with Susan Abbott, an anthropologist, he studied the Kikuyu tribe in Kenya. They presented their findings with their paper "Symptoms of Depression and Anxiety among Rural Kikuyu in Kenya." Dr. Klein, a native Brazilian, is now back in Brazil at the Instituto de Matematica Pura e Aplicada as associate professor. . . . **Carlie J. Coats, Jr.,** '78, has assumed the position of visiting professor of mathematics at Lehigh University.

XIX
Meteorology

Eugene B. Brock, S.M. '68, has moved from Robins Air Force Base in Georgia to Hickam A.F.B. on Hawaii where he serves as deputy commander. . . . **Julius Honig,** S.M. '53, works for I.B.M. in Palo Alto as a program manager. . . . **Robert Gammill,** Ph.D. '69, was recently appointed associate professor and chairman of the Computer Sciences Division of Mathematical Sciences at North Dakota State University.

XX
Nutrition and Food Sciences

Barbara J. S. Greenberg, S.M. '77, writes: "I am currently employed as a nutritionist in the Vermont Women, Infants, and Children Supplemental Food Program. During my one-and-a-half years with the program I have published numerous nutrition education pamphlets and coauthored a nutrition education book geared to low-income parents. I have also coproduced a television show on preschool nutrition for Southeastern Vermont Public Television. I was recently nominated for Outstanding Young Woman of America for 1978. This past spring I testified before the Senate Committee on Nutrition for continued funding of the W.I.C. program." . . . **Leonard P. Tannen,** S.M. '59, is director of production for the grocery products division of Great Atlantic and Pacific Tea Co. . . . **Marcus Karel,** Ph.D. '60, associate head of the department, has been named to the Food Engineering Hall of Fame. He is particularly well known as an expert on freeze-drying foods and for his contributions to the design of food and water systems in a weightless atmosphere — N.A.S.A. consulted with him for the Apollo and Skylab programs.

XXII
Nuclear Engineering

Jerome H. Goldberg, S.M. '60, senior construction manager with Stone and Webster Engineering Co., was recently elected a vice president there. . . . **Leonard S. Cohen,** S.M. '59, is vice president, director and cofounder of Scientific Leasing, Inc. of Framington, Conn. The company leases sophisticated medical and technical equipment nationwide. . . . **William R. Corcoran,** Ph.D. '71, is chairman-elect of the A.N.S. Nuclear Reactor Safety Division. He is located in Windsor, Conn., and directs the Nuclear Performance Department at Combustion Engineering. . . . **Scott Feldman,** S.M. '77, works on solar management research for the electric utility industry at Arthur D. Little.

How Meteorology Grew Into Atmospheric Science, But the Fog-Cutter Couldn't Cut It

Fifty years ago M.I.T.'s workers in meteorology were hardly more than a small family, as many teachers as students, innovative — even radical — workfellows equally at home with the exotic pleasures of skinny-dipping and the then-esoteric notions of air masses and frontal systems.

Their leader was Carl Gustav Adolph Rossby, an extraordinary Scandinavian who had come to the U.S. Weather Bureau in 1926. He quickly found the Bureau "too reactionary," and as quickly it found him "too progressive"; so Dr. Rossby chose instead to try explaining his ideas about atmospheric thermodynamics and storm fronts to the aeronautical engineers at M.I.T. who were preparing to fly through the stuff.

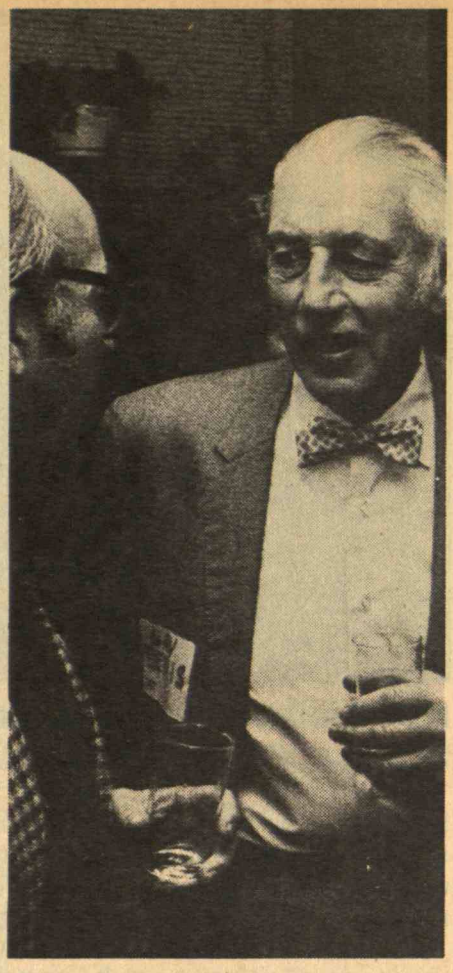
These were among the first meteorology classes in the nation, and by 1946 the field had so advanced that Dr. Rossby's small band had become the first Department of Meteorology in a U.S. university.

In those days predicting the weather in New England was hardly more than looking west, or perhaps south, to see what was coming, and how fast. Professor Rossby began the process of changing all that, and it's been continuing ever since — a unique marshalling of science and engineering to help birth at M.I.T. a wholly new science of weather and climate.

Highlights of this 50–year history were relived by some 200 of its participants at the Institute on October 27 and 28 during a 50th birthday celebration which attracted at least 25 per cent of the Department's living alumni. The early history was described with warm humor and nostalgia by Jerome Namias, S.M. '41, now of the Scripps Institution of Oceanography. Professor George W. Platzman of the University of Chicago recalled the momentous experiments which made weather data accessible to high-speed computers; Alan C. Bemis, '30, and Professor Bernard Haurwitz of Colorado State University provided some additional history; and Thomas F. Malone, Sc.D. '46, Director of the Holcomb Research Institute at Butler University, brought his crystal ball with which to propose the future.

The achievement of numerical weather prediction came in March, 1950, when Jule G. Charney, who is now Alfred P. Sloan Professor of Meteorology at M.I.T., and several colleagues (including Professor Platzman) brought their data and programs to ENIAC, the Electronic Numerical Integrator and Computer which had been built at the University of Pennsylvania and was then at Aberdeen Proving Ground, Md. ENIAC had

A semicentennial for Meteorology. Edward N. Lorenz, Sc.D. '43 (bottom left), chairman of the Department, convened this celebration of people who've been talking about the weather — and doing things about it — for half a century. That half century was detailed by Jerome Namias, S.M. '41 (previous page), and Alan C. Bemis, '30 (right), who recalled the Department's accomplishments (and some of the struggles). (Photos: Joel W. West III, '79)



18,000 vacuum tubes and 6,000 switches, and no other computer then extant was large enough. After 13 days and countless outages came the first 24–hour forecast, two weeks later another, and then in one week two more. The results, said Professor Platzman in the first Victor P. Starr Lecture on October 27, proved that large-scale atmospheric flows could be forecast. Professor Rossby, by then retired and back in Sweden, said the work marked "the threshold of a new era of applied meteorology," and Dr. Platzman regards this prophecy as fully consummated.

As Dr. Platzman's lecture neared the half-way point, a small I.B.M. computer in the corner of Room 10–250 was given the same numerical data which the room-sized ENIAC received for its first forecast; and as Dr. Platzman finished his tale of the 13–day effort at Aberdeen the little I.B.M. computer completed the same task and issued the same forecast.

After 50 years the unfolding story hasn't ended; indeed, it may only have begun. Dr. Malone, who taught at M.I.T. from 1941 to 1955, says meteorologists stand at the threshold of new responsibilities as "full-scale partners in the management of a vital natural resource" — meaning the atmosphere. Ever more accurate weather prediction over ever longer periods will remain an urgent goal, Dr. Malone said. But the real issue will be what he called "atmospheric resilience" — the capacity of the atmosphere to spring back when perturbed by pollutants, or to stabilize in new modes when perturbed by weather modification.

As the two-day celebration ended, Mr. Bemis, who worked on radar in the Department from 1939 to 1965, recalled the studies of cloud physics by Professor Henry G. Houghton which claimed world-wide attention in the 1950s. There was something about carrying cloud physics research equipment to the summit of Mount Washington in Mr. Bemis's venerable 1913 Rolls Royce, and then some stories of research on fog-cutting techniques along the coast of Maine. The cutter apparently didn't work, for the fog grew ever heavier, and the down-East accent ever thicker . . . — *J.M.*

M.I.T. INSIGNIA

A GOOD WAY TO REMEMBER

M.I.T. CHAIR. A traditional favorite made of selected northern hardwoods and finished in satiny black with gold trim and gold M.I.T. crest. In all black or black with cherry arms. each **95.00**

M.I.T. CHAIR CUSHION. Tough Duraleather cushion in deep red with grey piping and 2" thick foam filling. **13.00**

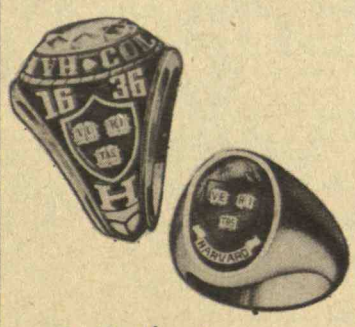
M.I.T. PLAQUE. Bronze seal mounted on solid walnut shield or rectangle. Comes with self-adhering brass nameplate. **27.95**
For two lines of engraving, add 7.00

M.I.T. INSIGNIA TIE. A distinctive way to show off the M.I.T. shield. Fine quality polyester with repeat pattern on maroon or navy ground. 3½" wide. **8.00**

SEND FOR INFORMATION ON YOUR JOSTEN'S RING. Traditional school ring can be made for any graduating class and major.

DIRECTOR'S CHAIR. Sturdy folding hardwood frame in natural or black finish. Seat and back in heavy white cotton duck with 3-color M.I.T. seal. **40.00**

DIRECTOR'S CHAIR with walnut finished hardwood frame. **47.00**



Send for information on your
JOSTEN'S RING

TR-1979

the Coop

M.I.T. Student Center
84 Massachusetts Avenue
Cambridge, Mass. 02139

Quan.		TOTAL
___	M.I.T. Chair, cherry arms	Express Collect 95.00 ___
___	M.I.T. Chair, all black	Express Collect 95.00 ___
___	M.I.T. Chair Cushion	13.00 ___
___	M.I.T. Insignia Tie in navy	8.00 ___
___	M.I.T. Insignia Tie in maroon	8.00 ___
___	Director's Chair ( ) natural, ( ) black	40.00 ___
___	Director's Chair in walnut	47.00 ___
___	Plaque	27.95 ___
___	Engraving	7.00 ___
	( ) Shield, ( ) Rectangle	

Name to be Engraved _____
Class of _____
( ) Please send information on Josten's rings

Please ship to: _____
Street _____ City _____
State _____ Zip _____
Ordered by: _____
Street _____ City _____
State _____ Zip _____
COOP # _____
☐ CHARGE MY ACCOUNT ☐ OR I ENCLOSE REMITTANCE

Mass. Residents: Add 5% sales tax (except ties).
Out-of-state Residents: No tax except when delivered in Mass.

SHIPPING AND HANDLING (Continental U.S.A.)

		N.E. States	East of Miss.	West of Miss.
Director's Chair	(per order)	2.50	3.50	4.50
Personalized Plaque	(per order)	1.25	1.75	2.25
M.I.T. Chair Cushion & Tie	(per order)	1.00	1.25	1.50

M.I.T. Chairs: Freight charges collected upon delivery.
Please allow approximately 4 weeks for delivery.

ALL PRICES SUBJECT TO CHANGE WITHOUT NOTICE

Alumnae Come to Dinner at W.I.L.G.

Students considering careers in politics should volunteer for campaign work, says Evelyn Murphy, former Massachusetts Secretary for Environmental Affairs. Dr. Murphy told a fall meeting of the Association of M.I.T. Alumnae (A.M.I.T.A.) that the familiarity with environmental and consumer issues gained through her own experience in campaign work led her to greater involvement in public service.

The meeting — following dinner prepared by members of the Women's Independent Living Group (W.I.L.G.), a 44–woman student community — was the first social gathering of alumnae and W.I.L.G. members, and it marks the alumnae's current philosophy toward women students: in the past they played a "motherly" role for M.I.T. women students; now no longer maternal, they have provided some financial and personal support for the development of W.I.L.G., and A.M.I.T.A. members serve on W.I.L.G.'s governing board. "A.M.I.T.A.'s relationship to women students is as a resource of established, technical women professionals in all areas of business and industry," says Susan L. Kannenberg, '61, President of A.M.I.T.A.

Alumnae and students alike found that Dr. Murphy painted an intriguing picture of the life of a successful woman in politics: She spent as much as 80 hours per week on her job (the emphasis shifted seasonally — town meetings in the fall, lobbying in the spring — but daily meetings with her staff were constant); to maintain her sanity under the pressure, Dr. Murphy stipulated that her weekends be entirely private time. Few of her staff members knew her home phone number — and they had been warned to use it only in extreme emergencies. — *Elizabeth Greene*

The Women's Independent Living Group invited members of the Association of M.I.T. Alumnae to dinner last fall, and the result was good company and lively talk. Alumnae, such as Marjorie Pierce, '22 (photo opposite), recounted the days when their women classmates numbered less than ten — mere "statistical noise," says Susan Kannenberg, '61, President of A.M.I.T.A. (Photo: Gordon R. Haff, '79)

12 Corporate Leaders Honored

Twelve alumni who are chairmen, vice chairmen, or presidents of leading business and industrial organizations in the U.S. received M.I.T. Corporate Leadership Awards at the Corporation Luncheon in Cambridge on December 1.

The recipients:

☐ **Robert D. Blythe,** '66, president of Munford, Inc., Atlanta, Ga.

☐ **David Brown,** S.M. '40, vice chairman of Halcon International, Inc., New York City.

☐ **Robert F. Calman,** S.M. '67, vice chairman of IU International Corp., Philadelphia.

☐ **Robert C. Ernest,** S.M. '59, president of Kimberly-Clark Corp., Neenah, Wisc.

☐ **Lawrence Gould,** '50, chairman, president, and chief executive officer of M/A-COM, Inc., Burlington, Mass.

☐ **Milton G. Hulme, Jr.,** '50, president and chief executive officer of Mine Safety Appliances Co., Pittsburgh.

☐ **J. Kenneth Jamieson,** '31, chairman of Crutcher Resources Corp., Houston.

☐ **James A. Newman, Jr.,** '37, vice chairman of Booz, Allen and Hamilton, Inc., New York City.

☐ **Frank Perna, Jr.,** 'S.M. '70, chief operating officer of Sun Electric Corp., Crystal Lake, Ill.

☐ **John E. Preschlack,** '54, president and chief executive officer of General Binding Corp., Northbrook, Ill.

☐ **William R. Thurston, Jr.,** '43, president and chief executive officer of GenRad, Inc., Concord, Mass.

☐ **Jervis C. Webb,** '37, president and chairman of Jervis B. Webb Co., Farmington Hills, Mich.

Early Decisions for the Class of 1983

Just over 200 "early decision" applicants were admitted to M.I.T.'s Class of 1983 late last year; Peter H. Richardson, '48, estimates that this represents about one-fifth of the total class.

There were 750 applicants for "early decision" for the Class of 1983, compared with about 650 a year earlier for the Class of 1982. Those not granted early admission will be reconsidered for regular admission during the spring.

As the Christmas holidays approached, Mr. Richardson urged M.I.T. students — especially freshmen — to visit their former high schools and particularly to seek out candidates for M.I.T. admission.

"M.I.T. is well known for its science and engineering," he said in *The Tech*, "but not so well known when it comes to social, political, and human kinds of things. Undergraduates' experiences can be an important glimpse of M.I.T. to teachers, counselors, and students.

"In particular," he said, "the Admissions Office wants it known that it believes M.I.T. is the place for women and minority students, and we want to help in getting this message to others in your home town."

K. F. Hansen

Hansen Is Associate Dean

Kent F. Hansen, '53, professor of nuclear engineering, is now associate dean of the School of Engineering, where he's filling the desk left empty by James D. Bruce, Sc.D. '64 *(see below)*. It's M.I.T.'s largest school and managing it is a major administrative undertaking.

Professor Hansen joined the faculty in 1961; he was executive officer of the Department of Nuclear Engineering from 1972 to 1974 and acting head of the Department in 1975. A graduate of M.I.T. in physics and nuclear engineering (Sc.D. 1959), he's considered an expert in nuclear reactor theory, fuel management, and safety analysis.

President Jimmy Carter nominated him in June, 1977, to be a commissioner of the Nuclear Regulatory Commission, but Professor Hansen's nomination failed of confirmation in the Senate.

Robert C. Seamans, Jr., Sc.D. '51, dean of the School, calls his new associate dean "a talented educator and a skilled administrator. As associate dean he will add strength and vitality to the School by virtue of his keen interest in the application of engineering to the needs of society."

J. D. Bruce

Bruce to Industrial Liaison

M.I.T.'s Industrial Liaison Program, through which more than 100 companies in the U.S., Europe, and Japan are brought into close relationship with teaching and research at the Institute, has a new director: James D. Bruce, Sc.D. '64, former associate dean Department of Electrical Engineering and Computer Science, where he is a specialist in information management systems and digital signal processing — thus assumes a key role in the M.I.T. Leadership Campaign. He succeeds Professor Samuel A. Goldblith, '40, who is now M.I.T.'s vice president — resource development; and Professor Goldblith says that one of Professor Bruce's primary goals will be "the continued development of both the Industrial Liaison Program and the M.I.T. Associates Program."

Professor Bruce first came to M.I.T. in 1958 as a graduate student in electrical engineering. He joined the faculty upon completing his doctorate and became executive officer of the Department in 1969, leaving that assignment to join the Dean's Office in 1973. He won the Gordon Y. Billard Award last June for his success in "applying his knowledge of computational systems to the management of large and complex academic structures."

Managing Those Old (But Useful) Books

A $100,000 grant from the Booth Ferris Foundation will permit the M.I.T. Libraries to begin planning a Resource Sharing Center to house Library materials which — though still important — have only occasional use. It's a vital project, says Jay K. Lucker, director of libraries; success could mean that the Institute could delay — perhaps indefinitely — building new library buildings, and it could be "a model for libraries thorughout the country." All libraries, he says, are plagued by the problem of increasing holdings while maintaining the accessibility of their collections.

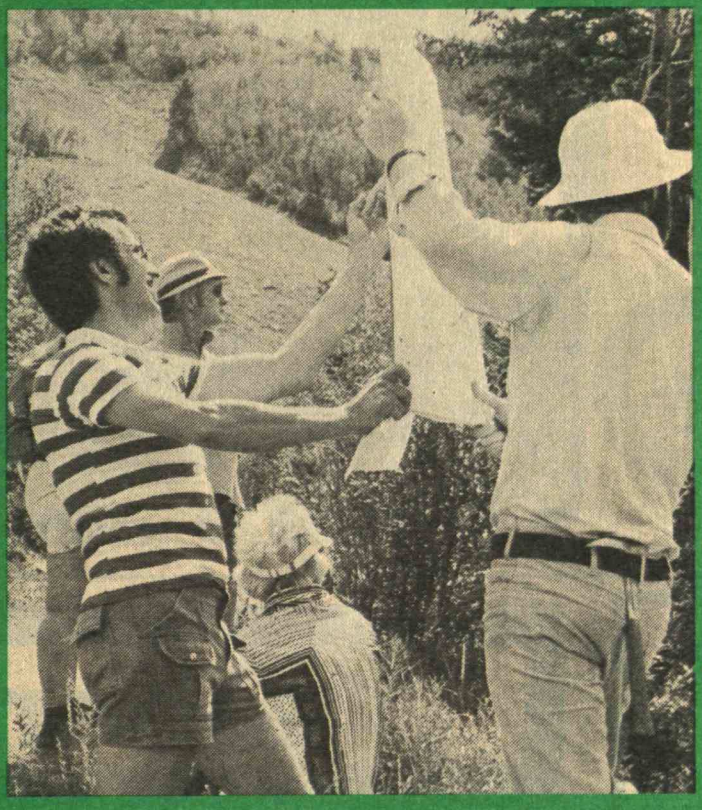
Technology Day 1979: Pops and Productivity

A unique blend of professional insights, friendship, and nostalgia await alumni at the 1979 Technology Day celebration on June 7 and 8.

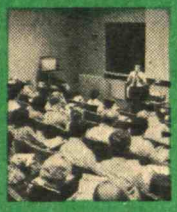
Plans include the traditional "Tech Night at the Pops" on June 7 and a full day of activities on June 8: a symposium on U.S. industrial innovation keynoted by Jordan J. Baruch, '47, Assistant Secretary of Commerce for Science and Technology, which will respond to President Jimmy Carter's project to stimulate U.S. innovation and productivity; the dedication of the new Whitaker College of Health Sciences, Technology, and Management; and special presentations on current topics in the Schools of Science and Engineering. For further details: Joseph J. Martori, Room 10–115M, M.I.T., Cambridge, Mass. 02139.

"I have never interacted with such a consistently enthusiastic and persistent class before. Whatever successes we achieved as a faculty are due to the fantastic synergy which was generated during the week.

The vibrations were super!"



Professor Stanley R. Hart
Director
1977 Alumni Summer College
in Aspen



Cambridge
July 8–13

Aspen
July 15–20

MIT Alumni Summer College 1979

The MIT Alumni Summer College is a five-day academic seminar sponsored by the MIT Alumni Association and the MIT faculty for alumni and their families.

The program will be highly participative with lectures and discussions led by members of the MIT faculty. There will be special programs for children and recreational activities for all members of the family.

For further information return this coupon to:

MIT Alumni Summer College
The Alumni Center
77 Massachusetts Ave.
Cambridge
Massachusetts 02139

Name

Address

Class

Phone

Over 1,550 pints of blood went to the Red Cross during M.I.T's 1978 fall blood drive — not quite a new record and somewhat short of the hoped-for 1,700 pints but "not bad," said Chairman Thomas P. Crowley, '79, of the Technology Community Association. Theta Chi led the fraternities with 87 per cent participation by its residents, and "Vardebedian House," a unit of the new West Campus houses, led the dormitories with 91 per cent. A few donors were lucky enough to time their gifts with a serenade by the Chorallaries. (Photo: Joel West, '79, from The Tech)

HOW TO LAND A JOB WITH BOEING:

Knock.

If you're a graduate in AE, CE, EE, ME or Computer Science, drop by your campus placement office. There's all kinds of information about The Boeing Company and opportunities in your specialized field. After all, opportunity only knocks once.

BOEING

An equal opportunity employer.

Can you identify the chemical engineer in this group?

You're right if you said all of them. And you're right again if you conclude that Kodak offers a wide choice of career paths for individuals with strong technical skills. So it shouldn't be a surprise that our top management team is predominantly individuals with engineering backgrounds. At Kodak plants in Windsor, Colo.; Rochester, N.Y.; Kingsport, Tenn.; and Longview, Tex., you'll find chemical engineers in hard hats performing vital production staff functions and others deeply involved in design and development. Other chemical engineers are more often in business suits, calling on customers all over the country as Technical Sales Representatives. And some don't stray too far away from the satisfactions they find in the research labs. Incidentally, it would be very easy to find this kind of occupational variety among mechanical, industrial, or electrical engineers at Kodak.

Some of the members of this group found a bachelor's degree was all that was needed to prepare them for a challenging job. Other positions are better suited for someone who has completed a master's degree. If you prefer to work now and study later, the Kodak Educational Aid Program offers opportunities for full- or part-time learning. Those bent on a career in research usually apply to us with Ph.D in hand.

At Kodak, the emphasis is on technical innovation as a blueprint for keeping pace with our changing world. It's taken us—and it can take you—far from our photographic origins. For example, our basic expertise in photographic emulsion coating was the springboard to the development of a new clinical blood analysis system for health care. Our need for chemicals in photographic manufacturing led to the development of a multiplicity of products including fibers, textiles, and dyes for apparel and home furnishings. And our imaging abilities gave us an opportunity to make and market quality business equipment like microfilmers and copier-duplicators.

When a company is open to new directions, the people who work for it should expect changing horizons in their individual roles as well. Where the future can take you at Kodak depends on a lot of things—like personal preferences, performance on the job, and available openings. What we can promise is the opportunity to explore many conventional engineering choices plus a lot of other vital professional options.

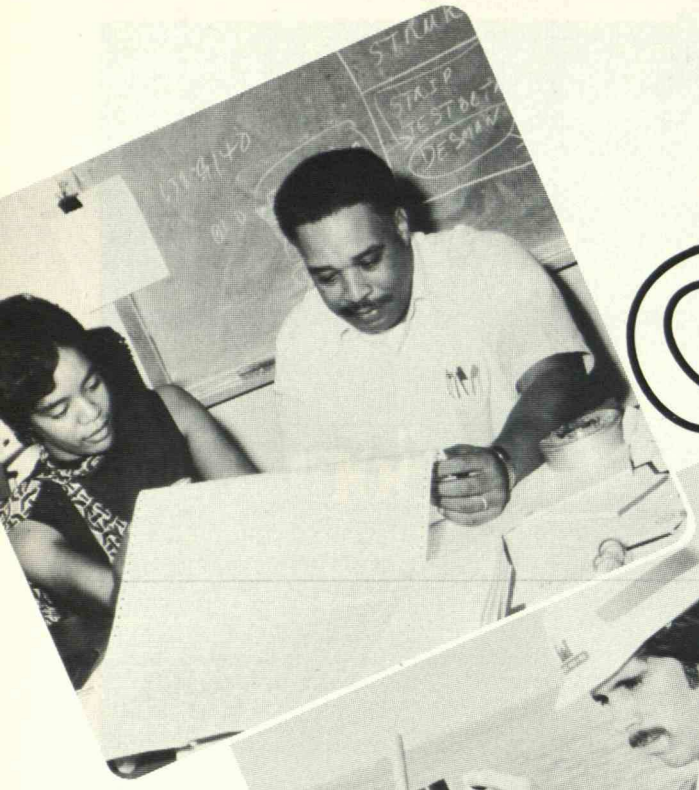
Begin by contacting Business and Technical Personnel, Eastman Kodak Company, Rochester, N.Y. 14650.

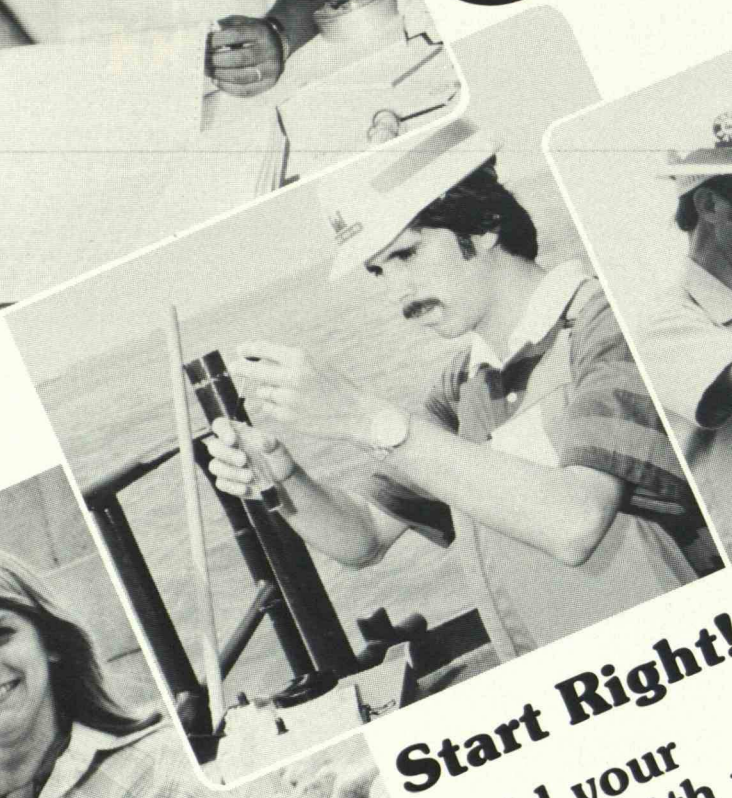
Kodak

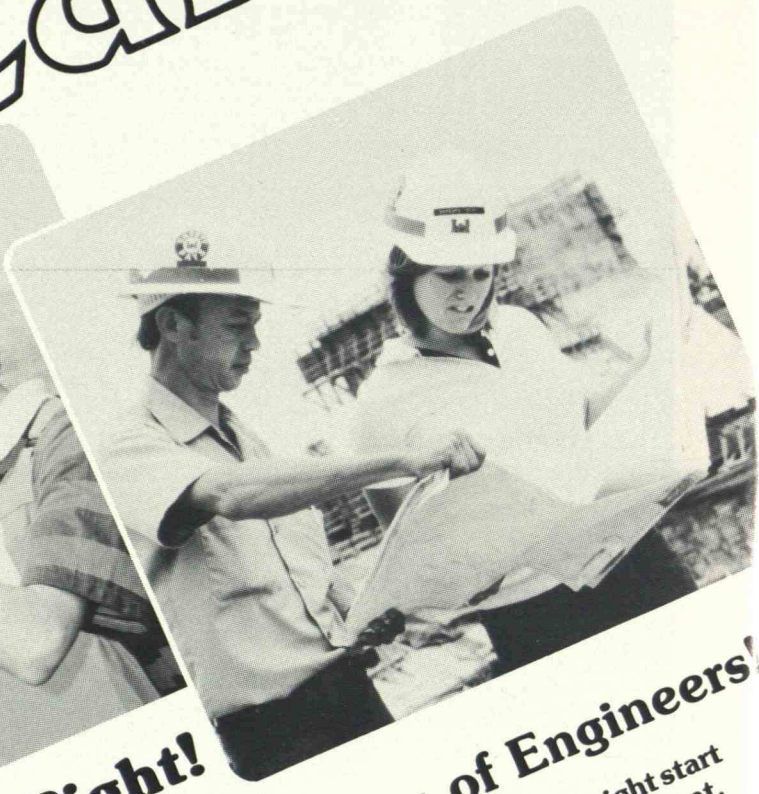
An equal-opportunity employer (f/m) manufacturing photographic products, fibers, plastics, and chemicals with plants in Rochester, N.Y.; Kingsport, Tenn.; Windsor, Colo.; Longview, Tex.; Columbia, S.C.; Batesville, Ark.; and sales offices throughout the U.S.A.


A Call for Professionals
...from The Idea Source!
More than a fancy synonym. The Idea Source aptly describes the advanced scientific and engineering developments of The Aerospace Corporation.
From our primary role of systems architecture and engineering for the Air Force Space and Missile Systems Organization, to our work on behalf of other agencies involved in national security, The Aerospace Corporation stands out as the source of tomorrow's ideas.
As in any human enterprise success depends primarily on the quality of the people involved. That's why we at Aerospace have gathered together over 1700 engineers and scientists: more than half of which hold advanced degrees and one in four a doctorate.
This is also why we invite you to investigate these unique career opportunities...opportunities which can change your involvement from a single aspect to the entire system spectrum...opportunities which can involve the individual from concept and design through test and successful operation.
We seek technical professionals with training in engineering science, physics, mathematics or computer science with B.S., M.S., or Ph.D. degrees. If you are interested in working with superior technical people, please forward your resume in confidence to:
Professional Placement
The Aerospace Corporation
2350 East El Segundo Blvd.
El Segundo, California 90245
Equal Opportunity Employer
U.S. Citizenship Required
The Aerospace Corporation
The Idea Source

careers







Start Right!

Build your career with the Corps of Engineers!

As the world's largest engineering and construction organization, the Corps can give you the right start toward a career in engineering, architecture, or resource and environmental planning and management.

Your career with the Corps in our world-wide operations may involve planning for the development of the nation's water resources, preserving our natural environment, opportunities to design and supervise the construction of energy generation facilities, family housing, entire cities, and more.

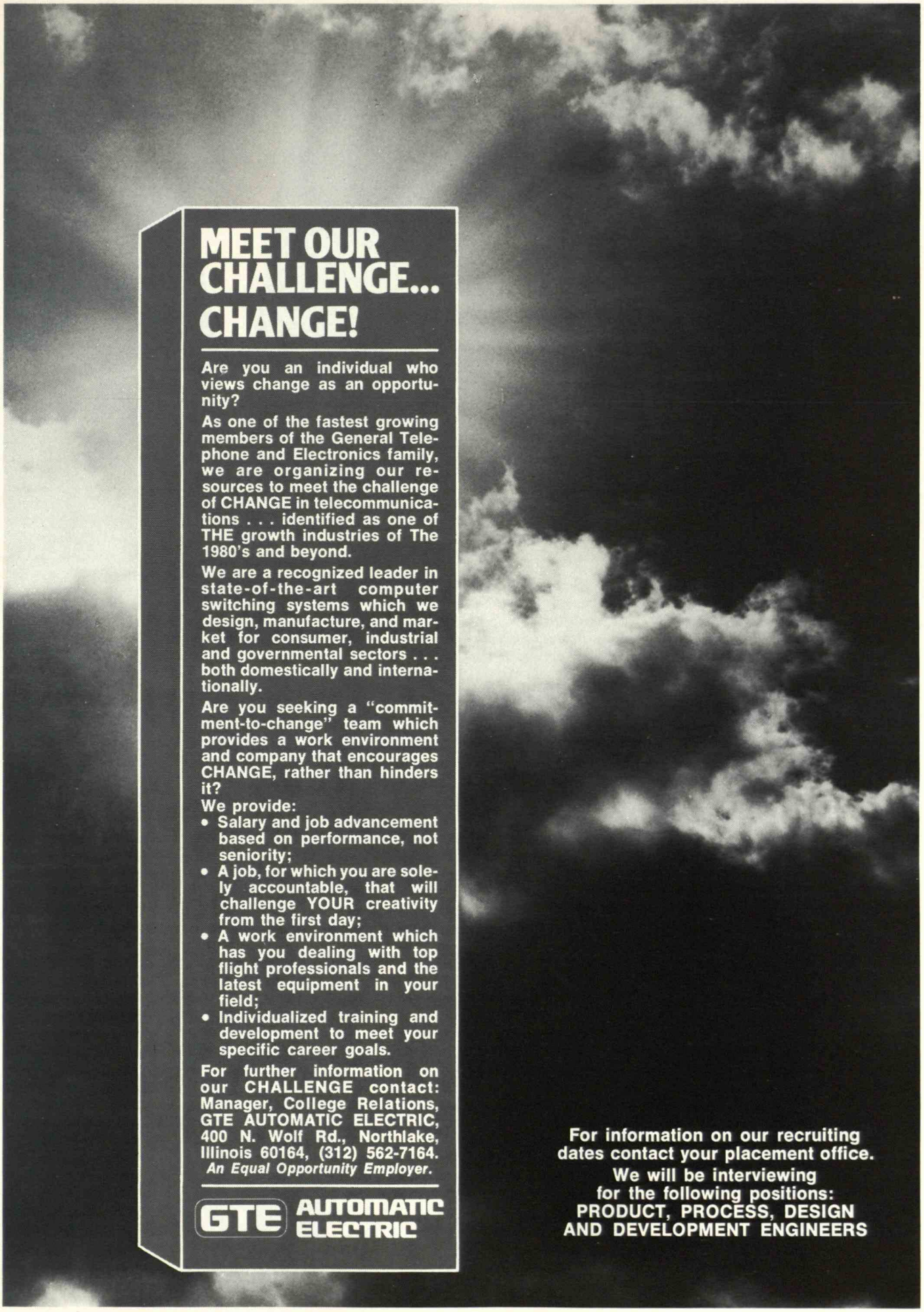
Your talents and skills will be used in building a quality life for today and for future generations.

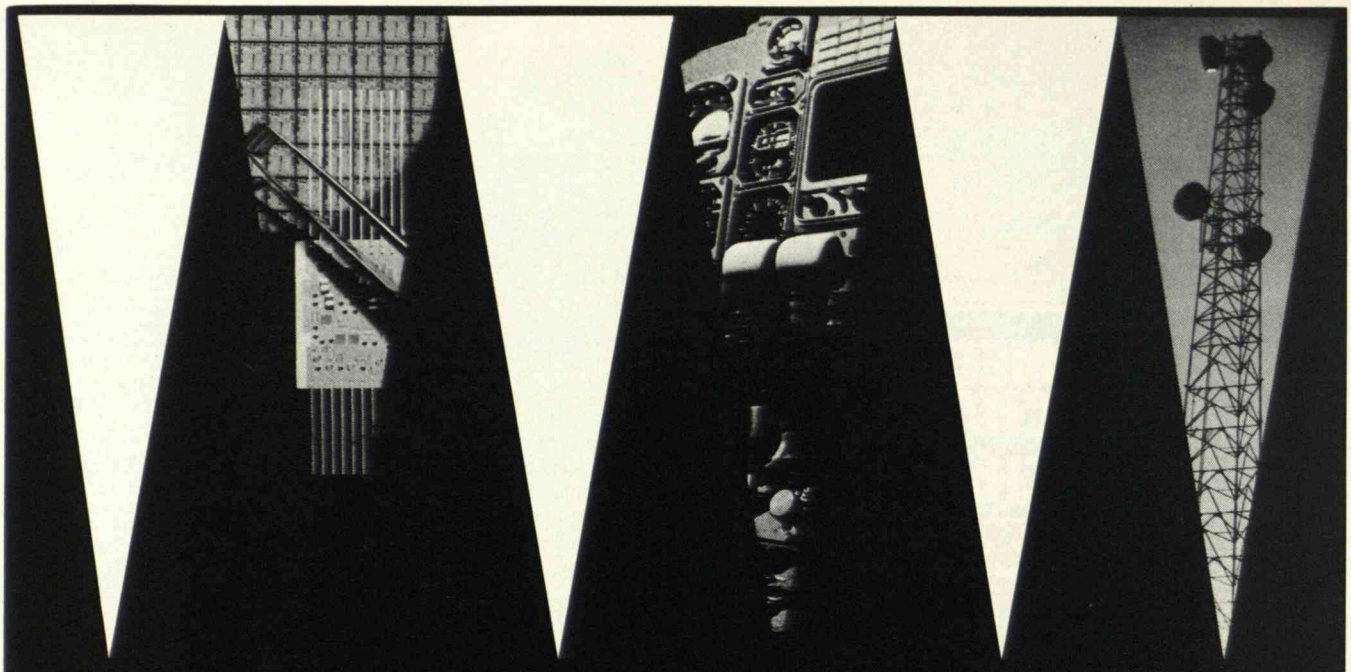
Because the Corps has been building careers for more than 200 years, the fulfillment of an exciting future awaits you.

Write us and we will tell you more about civilian career opportunities with the Corps of Engineers.

An Affirmative Action Equal Opportunity Employer

Corps of Engineers
Department of the Army
Washington, D.C.
20314


MEET OUR CHALLENGE... CHANGE!
Are you an individual who views change as an opportunity?
As one of the fastest growing members of the General Telephone and Electronics family, we are organizing our resources to meet the challenge of CHANGE in telecommunications . . . identified as one of THE growth industries of The 1980's and beyond.
We are a recognized leader in state-of-the-art computer switching systems which we design, manufacture, and market for consumer, industrial and governmental sectors . . . both domestically and internationally.
Are you seeking a "commitment-to-change" team which provides a work environment and company that encourages CHANGE, rather than hinders it?
We provide:
• Salary and job advancement based on performance, not seniority;
• A job, for which you are solely accountable, that will challenge YOUR creativity from the first day;
• A work environment which has you dealing with top flight professionals and the latest equipment in your field;
• Individualized training and development to meet your specific career goals.
For further information on our CHALLENGE contact: Manager, College Relations, GTE AUTOMATIC ELECTRIC, 400 N. Wolf Rd., Northlake, Illinois 60164, (312) 562-7164.
An Equal Opportunity Employer.
GTE AUTOMATIC ELECTRIC
For information on our recruiting dates contact your placement office.
We will be interviewing for the following positions:
PRODUCT, PROCESS, DESIGN AND DEVELOPMENT ENGINEERS



Accept The Rockwell Electronics Challenge!

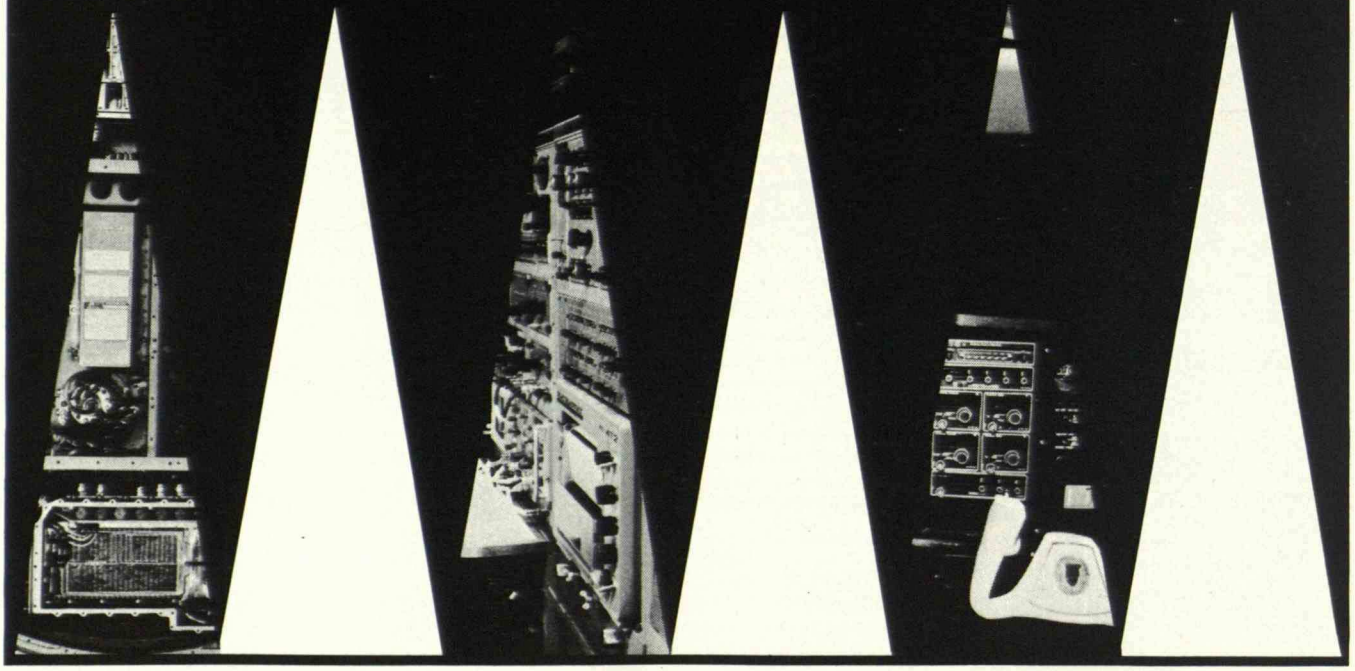
You're about to make the most difficult move of your life...selecting your first full time job. We'd like to help you make the right decision. That's why we're putting down the cube and bringing things to a head.

When it comes to Electronics, Rockwell goes across the board. As a recognized world leader in sophisticated electronic components, products and systems, we span the globe serving a vast array of markets in avionics, telecommunications, navigation, missiles, sensors, systems integration, and electronic devices.

Rockwell offers hundreds of career choices to a number of choice people. If you're an EE, IE, ME, Physics, Math or Computer Science major...we invite you to accept the Rockwell challenge. Contact your placement office today for an immediate interview.

Rockwell International
Electronics Operations

An Equal Opportunity Employer, m/f



analyst infers how this part of the world process will evolve in reality, and more ambitiously, how its evolution will be affected by specific policy initiatives.

The fatal weakness with this approach, for all policy issues of any significance, is that the aspects of the world ignored are usually equally or more important to determining how the process evolves than those parts included in the analysis. Nor does extending the scope of the analysis remedy matters; first, because data requirements expand geometrically with scope (and much of the data for the expanded study will prove to be unavailable or not available on a timely basis — the world just keeps rolling along, outmoding all data collected in the past — forcing the analysts to make heroic guesses about data values), and secondly, even if the data were available, theories are not available to explain the interrelationships among the expanded data-set.

Now, you could reply, as do many policy scientists, that we simply need to collect more data and to employ more analysts to study the interrelationships among the larger data-set, thus making our analytical models of the world more accurate. But isn't it obvious by now that more of the same isn't going to lead to better results? Just in the area of the "national reprocessing decision," as you term it: how would you include in your analytical model the influence on the future costs and economic benefits of reprocessing of the need to keep the dangers of reprocessing within socially acceptable limits? How, for instance, would you even begin to describe analytically the obviously important interrelationship between future reprocessing costs and the need to keep the risk of radiation contamination to workers and the environment to an acceptable level, recognizing that new information is constantly changing that interrelationship.

Since I have spent most of my adult life working on policy analysis, I'm not ready to write it off as a useless endeavor (although I must admit that I have come very close to this several times in the past). But what I am absolutely clear on is that more abstraction, more complexity, more computerization — in other words, more standard scientific sophistication

"So long as you believe that the only important aspects of a policy issue are those that can be treated within the highly restricted confines of a quantitative, analytical model, you will be blind to evidence that doesn't fit within the model."

— is not going to improve the record of policy analysis.

To be able to give truly useful advice to policymakers, we analysts will first need to greatly improve our own understanding of the world process, for which we must develop routes to understanding not embraced by conventional scientific modes of analysis. You could help in this task, but first you must be convinced that the tools you are presently working so hard to master are inadequate. To do this, I want to make you uncomfortable with your present, educationally derived beliefs, sufficiently uncomfortable so that you begin to ask whether there aren't other, better ways to relate to the world. Did it ever occur to you that some of those people who are saying things that seem wrong or irrational to you are really telling it like it is — but you just can't understand because the concepts that you use to think about the world are getting in the way?

Unquestioned Observations of Reality

My papers obviously have upset you greatly. Why? Perhaps my conclusion that near-term use of plutonium fuels would be a dangerous, unnecessary gamble with a low probability of producing significant economic gains runs counter to the conclusion you have been attempting to support in your thesis. If so, your upset would be understandable. But, I think perhaps you were disturbed for a different reason — because acceptance of these papers would imply rejection of some beliefs (for example, in the desirability of continued technological advance) that are very important to you at the moment. At the conscious level, these beliefs probably don't seem to you to be beliefs at all, but rather, self-evident truths about the world. Actually, however, they are not immutable truths about the nature of reality, but merely working assumptions (although very important ones!) that provide a guide for analyzing, evaluating, and making decisions about the world.

I would like to help you gain an appreciation that came to me only slowly, painfully, and with much difficulty: how our intellectual concepts and beliefs limit our ability to perceive what is really happening in the world. When the world "was" flat, the heavens "had" to move around the earth. We see the world through the blinders of our own beliefs. When the world's behavior resists our expectations, as now seems to be the case in many areas of policy analysis, we need to question whether some of our important beliefs are in accord with reality. Unfortunately, our most basic beliefs are seldom accessible to our conscious mind: they appear to us as simple, unquestionable observations about reality.

For me, an important insight into my own belief structure occurred when, one day, I *saw* that furtherance of individual freedom might not necessarily be good. This came as a shock, since I had previously judged entire societies by the extent to which they furthered "individual freedom. My belief in the primacy of individual freedom was so fundamental that I had never thought to ask whether greater freedom might possibly make people worse off.

So long as I *believed* that more individual freedom was unquestionably better than less, I was unable to see any evidence to the contrary. I saw every suggestion toward less individual choice, less personal freedom as a threat to happiness, never perceiving the possibility that less freedom might make people happier by giving them a greater sense of security, more of a sense of identity with the world around them, or a closer relationship with other people. Once the question was raised, it became obvious that I had assumed an equality between individual freedom and individual welfare — an assumption that had no empirical basis and, moreover, one that would not even be seriously considered by vast numbers of people in the world (for instance, those raised in the context of traditional oriental thinking).

To realize that my intellectual concept of "individual freedom" had little basis in reality opened my eyes to unseen aspects of the world. Similarly, so long as you believe that the only important or relevant aspects of a policy issue are those that can be treated within the highly restricted confines of a quantitative, analytical model (such as the one you

"We see the world through the blinders of our own beliefs. When the world's behavior resists our expectations . . . we need to question whether some of our important beliefs are in accord with reality."

indicate you are using in your thesis), you will be blind to evidence that doesn't fit within the model.

To truly see that one of your own beliefs is just an assumption can be liberating. This experience, though, is not amenable to precise programming. You must stretch your mind, envelop your beliefs with contrary thinking, and allow your imagination to roam into forbidden territory without automatically rejecting its perceptions as "absurdities." Be open to life's teachings which, if my life provides any guide, will soon provide you with ample evidence of the fallibility of many of your most cherished beliefs. Chuang Tsu, a Chinese sage of ancient times, said this about people's beliefs: "Our words fly off like arrows, as though we knew what was right and wrong. We cling to our point of view, as though everything depended on it. And yet our opinions have no permanence: like autumn and winter, they gradually pass away."

You will not experience the arbitrary nature of your beliefs by reading more scientific, analytical books, or by just thinking about them. Something or someone outside of you must jolt you into opening your eyes, perhaps just for a moment, to an aspect of reality that doesn't fit comfortably in your present belief structure. If this happens, hang on to it! Expand on it, explore it. Don't suppress it and deny it. Rather, ask whether some of your previously-held beliefs need to be opened up to make room for a richer reality.

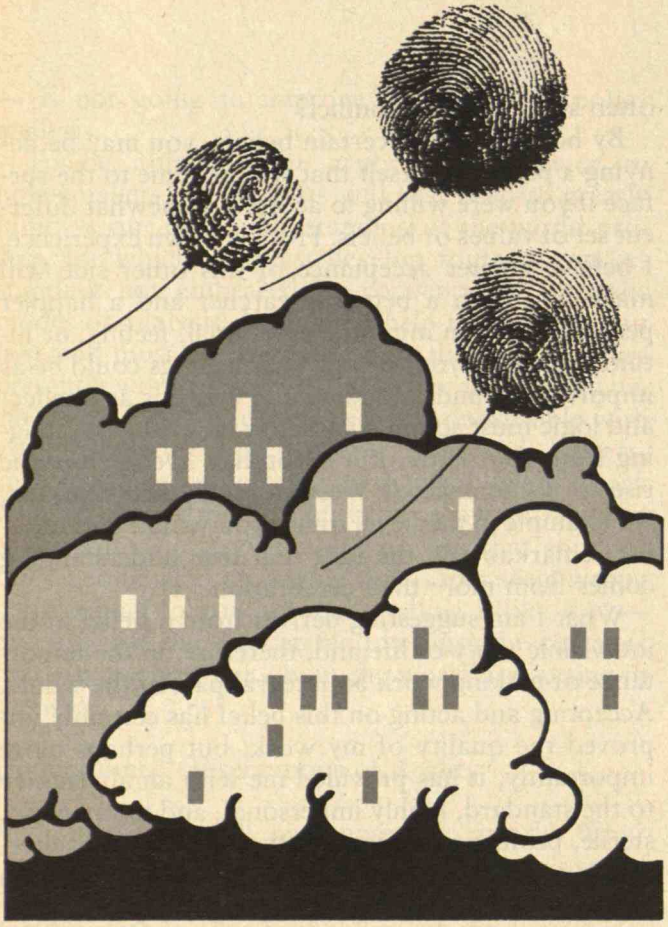
The Indivisible Unity of Life

I would like to change the way you think because it is important for you and important for the world. The old ways were good for old times, but they aren't working any more, either personally or socially. If you go on trying to fit the world into the old ways of thinking, you will be unhappy and confused and will be unable to contribute much to helping the world, our country, your family, or yourself through these troubled times. Do you understand why nuclear power isn't being embraced eagerly by the energy-hungry peoples of the world, or why the demands of your "job" and of your "personal life" so often seem to be in conflict?

By holding fast to certain beliefs, you may be denying a part of yourself that would come to the surface if you were willing to accept a somewhat different set of values or beliefs. From my own experience, I believe greater acceptance of this other side will make you both a better researcher and a happier person. I have in mind the emotional, feeling, or intuitive parts of your being. That feelings could be as important to understanding and analysis as intellect and logic must sound completely crazy to you, judging from your letter. But if you had lived before the rise to dominance of Western, analytical thinking, for example in medieval times, you would find nothing remarkable in the idea that true understanding comes from more than cerebration.

What I am suggesting derives from a belief in the indivisible unity of life and, therefore, in the importance of making work an integral part of the whole. Accepting and acting on this belief has certainly improved the quality of my work, but perhaps more importantly, it has provided me with an alternative to the standard, highly impersonal, and to my mind, sterile, professional career path. Access to this alternative is a natural outgrowth of treating your life as an integrated whole, not attempting to separate your "professional" from your "personal" life. Isn't it obvious that both aspects of your life will be enriched if you accept them as complementary parts of experience and consciously try to make each one supportive of the other? My own life has become more fulfilling for me since I stopped trying to pretend that I was two people, one at the office and one at home. Now although not all my professional colleagues are my close friends, nor vice versa, I am the same person to them all — leaving me less confused than previously about who I am or what I am doing with my life.

To be able to integrate your life, however, you will first need to re-examine your unquestioning belief in the superiority of "objective" over "subjective" research, a belief apparent in your condemnation of what you consider subjectivity in my writing. Until you relinquish this belief, you will be afraid to approach work with feeling as well as intellect for



"By drawing on all my perceptions of the world, I obtain a more complete and coherent view of world processes that are unfolding than would be possible if I limited myself only to information that I process intellectually and analytically."

fear of losing your much-valued objectivity. But, pure "objectivity" doesn't exist, since any observations, experiments, or analysis must always be done by a person, who inescapably must have values, emotions, and feelings that influence his or her work. This is, of course, exactly the point being made by Laplace in the quotation you cite as support for the superiority of objective analysis: "Our passions, our prejudices, and dominating opinions, by exaggerating the probabilities which are favorable to them, and by attenuating the contrary probabilities, are the abundant source of dangerous illusions." *(A Philosophical Essay on Probabilities)*

You seem, however, to believe that because you *desire* to be objective, you will be immune to those passions, prejudices, and dominating opinions which "are the abundant source of dangerous illusion." What nonsense. I am sure that Laplace would agree with me that those most likely to be led into dangerous illusions by their emotions are those who would deny most vehemently that emotion played any role in shaping their opinions about "objective" truth.

Rather than attempting to deny or suppress the obvious truth that I am a feeling as well as a thinking person, I celebrate it! And, then, because I recognize that I will be the first to be misled if I do not look the truth straight in the face, I guard against the universal, human tendency to favor one's emotional positions. I have no desire to deny that my views of the world influence my work. You term this "subjectivity" and denounce it soundly. I term it "wisdom" and recommend it highly. By drawing on all of my perceptions of the world, I believe I obtain a more complete and coherent view of the world processes that are unfolding than would be possible if I limited myself only to information that I process intellectually and analytically. In a sense, I work backwards from my overall view of the world to the specifics of a given problem, applying the tests of logic and evidence to check the correctness of the perceptions derived initially from feelings and intuitions as well as from thinking. I believe that the competence and usefulness of my work have increased enormously since I began to apply this integrated approach.

The Costs of Uncertainty

Though I don't wish to interfere with the more important message of this letter, perhaps some explanation of my methods will help you to see that my view of the world and approach to research are not incompatible with the goal of improving public policy.

You criticize me for not attempting "a dynamic treatment of reprocessing economic cost-benefits." I don't know what you mean by this phrase, but I can explain why I didn't use present-worth calculations in my analysis.

There are many conceptual problems with time-discounted, cost-benefit analysis. To mention only two: What is an appropriate rate of time discount? How do you make commensurable the narrow dollar costs and benefits of reprocessing and the non-dollar "costs" of increased risk of nuclear war? If one were to incorporate into the analysis all of the possible ways of resolving the controversies surrounding cost-benefit analysis, far from illuminating the consequences of alternative policies on reprocessing, the resulting analysis would submerge them deep into the murkiest of waters.

My objective in all of my work is to explain as clearly and simply as possible what is going on in the world and what is likely to happen if the government (or a company, or an individual) chooses one course rather than another. Thus, I desire to avoid complexity and obscurity whenever possible; and in the case at hand, it does turn out to be possible. First, because the evidence (not my personal prejudices) suggests that reprocessing, if undertaken in the near future, would very likely be unprofitable. There is no need to discount a future stream of losses to determine that the action leading to these losses is economically undesirable. Second, the real options in the reprocessing decision are to go ahead now or to defer the decision to a later date. Since this later date need be only a relatively short time in the future, say 1985, most of the stream of economic benefits (or losses) resulting from choosing the first option would be available under the second. Again, looking at the issue in this way is both clearer and more correct than the usual time-discounted cost-benefit evaluation, which assumes that we are faced with a once-and-for-all decision on whether or not to reprocess.

I have analyzed these two options in a formal, quantitative format in my testimony for the California Energy Commission in the proceedings of the United States Nuclear Regulatory Commission to determine whether to approve wide-scale use of plutonium fuels. In this instance, I was addressing an audience of experts and thus I considered it acceptable to use a relatively complex analytical framework.

In my testimony, I placed the reprocessing decision in a formal, quantitative structure because I wanted to make an important point about the advantages of deferring decisions in situations of great uncertainty — exactly the point you castigate me for making in the concluding section of "The Myth of Uranium Scarcity." Briefly, the point I make in both places is that the decision to wait (to defer decision) has the advantage that one gains more information as time passes, providing a better basis in the future for assessing the costs and gains of a definite decision. This is the principle that is captured in the academic models of sequential decision theory.

In "The Economics of Uranium and Plutonium" I did modify the exposition by focusing on a central case for quantitative analysis, using values for the key variables that were more favorable to reprocessing profitability than those that seemed most likely on the basis of extensively documented evidence. This analysis showed that even if such favorable values were to be realized, reprocessing would be unprofitable. I did this because there is no shortage of analyses that use a combination of values and technical assumptions that would, if correct, make reprocessing very profitable. I wished to make, as clearly as possible, a convincing counter-demonstration to those studies. Far from ignoring uncertainty, as you assert, I always stress that the future is very uncertain. In this essay, I focused attention on the most important implication of the economic uncertainties about reprocessing: that even if all uncertainties were resolved favorably for repro-

"To be able to give truly useful advice to policymakers, we analysts first need to greatly improve our understanding of the world process, for which we must develop routes to understanding not embraced by conventional scientific modes of analysis."

cessing profitability, widespread implementation of this dangerous technology would reduce the cost of nuclear electricity to the customer by less than one per cent.

What I did not do is to treat uncertainty in the "decision-analytic" framework you apparently favor. I rejected this methodology for the same reason that I avoided use of discounted cost-benefit flows — because it would obscure and confuse important conclusions that emerge clearly using simpler, more understandable approaches.

The Role of the Analyst

You accuse me of relying on personal opinions, feelings, and subjective assessments of likelihood as the major bases for my conclusions. Yet "The Myth of Uranium Scarcity," which you cite as the premier example of this failing, is almost entirely a compendium of official government analyses of uranium availability and cost, and it is on these analyses — not personal opinion or prejudice — that I base my conclusion that supplies of relatively low-cost uranium appear ample to meet expected nuclear fuel needs in this century and, probably, well into the next century.

You seem angry at me because I reach any conclusions at all, equating this act with bias, subjectivity, advocacy, and bad scholarship. You put me in a box labeled "policy analyst," which by your definition precludes having any opinions, no matter how well-informed. But I don't accept your box. I have no intention of performing my work within such arbitrary and self-defeating limits. Out of my own experience, I believe that anyone who limits himself to your definition of "policy analysis" will provide policymakers with nothing of value.

My objective is to educate and advise policymakers about the issues on which I work. To do this, I must necessarily reach conclusions or, in the words you use pejoratively, form opinions. A policymaker wants the opinions of his or her advisors — not ill-informed, emotionally grounded opinions, of course, but opinions nevertheless. You seem to believe that a policy analyst ought to be a policy eunuch. But an advisor without opinions is as useless as a dictionary without definitions. The very reason a policymaker turns to an advisor is because he or she does not have the time and expert knowledge required to study and evaluate all of the contradictory evidence and views pertaining to a controversial issue. He depends upon his advisors to do this for him.

Thus, I consider the act of forming an opinion about what constitutes appropriate policy to be not only a legitimate part of my work but one of its major objectives. This objective is in no way incompatible with high standards of scholarship nor does it preclude fair-minded and balanced assessment of the evidence. The extent to which my work on reprocessing and uranium may be more educational and therefore more helpful than others is, I trust, a result of my partial sucess at illuminating the truth of the situation, not because I have given in to my prejudices or distorted evidence.

Sincerely,
Vince Taylor

Suggested Reading

The following are some of the books that have helped me gain a better understanding of the world and myself:

Edward Abbey, *Desert Solitaire,* Ballantine Books, New York, 1968. A celebration of the beauties of the desert and a condemnation of industrial tourism in the National Parks. If one has difficulty in understanding how it can be better to arrange things so that fewer people can see less at the cost of greater effort to themselves, this book may help.

W. A. Bentley and W. J. Humphreys, *Snow Crystals,* Dover Publications, New York, first published in 1962. 2453 illustrations of individual snowflakes whose unrelenting beauty will blow your mind.

Stewart Brand (editor), *The Last Whole Earth Catalog* (or any other *Whole Earth Catalog*), Random House, New York, 1971. It's hard to explain how a catalog of books and goods can change your way of seeing the world, but this one does.

Carlos Castaneda, *The Teachings of Don Juan: Yaqui Way of Knowledge,* Pocket Books, New York, 1974. A spellbinding, persuasive account of one man's attempt to gain access to another reality.

A. R. Luria, *The Mind of a Mnemonist,* A Discus Book, published by Avon Books, New York, 1968. The story of a man whose mental functioning is so amazing and bizarre that it would not be creditable if it were not written by a highly reputable psychologist.

Frederick S. Perls, *Gestalt Therapy Verbatim,* Real People Press, Lafayette, Calif., 1969. To understand the world, one must understand one's self.

Snell Putney and Gail J. Putney, *The Adjusted American: Normal*

Neuroses in the Individual and Society, Harper & Row, New York, 1964. More than any other book I know, this book shows how the standard assumptions and beliefs of society limit our thoughts and perceptions.

E. F. Schumacher, *Small Is Beautiful,* Harper Torch Books, Harper & Row, New York, 1973. The only book I know on economics that speaks directly to the serious problems confronting the world today. His chapter entitled "Buddhist Economics" brilliantly and concisely reveals the deficiencies in conventional economic thinking.

Chogyam Trungpa, *Cutting through Spiritual Materialism,* Shambahla Publications, Berkeley, Calif., 1973. An exceptionally lucid exposition of Buddhist thought and its application to Western living.

Lao Tsu, *Tao Te Ching,* translated by Gia-Fu Feng and Jane English, Vintage Books, Random House, New York, 1972. This book contains the essence of Taoism which, to quote from the Introduction, "has for 2,500 years provided one of the major underlying influences in Chinese thought and culture." Whereas Confucianism is concerned with day-to-day rules of conduct, Taoism is concerned with a more spiritual level of being.

Immanual Velikovsky, *Worlds in Collision,* A Kangaroo Book, Pocket Books, New York, 1950. An account of the earth's past, based upon traditional sources of history, that is totally at variance with established theories of geology and astronomy. Guaranteed to stretch the limits of what you consider to be possible.

Alan W. Watts, *The Wisdom of Insecurity,* Vintage Books, Random House, New York, 1951. Alan Watts has written many books on Eastern ways of thought, all of which I recommend.

Further Reading

Is Plutonium Really Necessary?, Pan Heuristics, Los Angeles, Sept., 1976 (Revised).

The Myth of Uranium Scarcity, Pan Heuristics, Los Angeles, April 25, 1977.

How the U.S. Government Created the Uranium Crisis, Pan Heuristics, Los Angeles, June, 1977 (Revised).

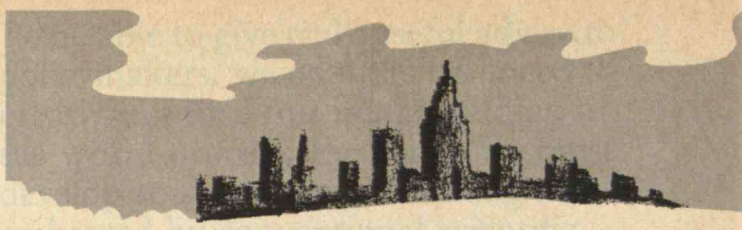
V. Taylor, "The Economics of Uranium and Plutonium," in A. Wohlstetter, et al., "Moving Toward Life in a Nuclear Armed Crowd?", *Minerva,* Volume XV, Numbers 3 and 4 (combined issue), Autumn-Winter, 1977.

Prepared Testimony of Dr. Vince Taylor in the Matter of GESMO, prepared for the California Energy Resources and Development Commission, Pan Heuristics, Los Angeles, March 4, 1977, Chapter A, "Reaching a Decision on GESMO."

About **Dr. Taylor's** background, he writes:

"I started my professional career with much the same beliefs and attitudes as the student in his letter, derived from an excellent education, first at Caltech, where I obtained a bachelors degree in physics, and then at M.I.T., where I studied for my doctorate in economics. Before completing my dissertation, I joined the Economics Department of Rand Corp. (1961), where I finished my thesis and worked for nine years, applying highly quantitative methods of analysis to a variety of problems, ranging from military theory to cost-benefit analyses of health-care delivery systems. After leaving Rand in 1970, I spent approximately four years doing economic modeling and statistical analysis of the stock market, and I developed a computer-based model that successfully predicted price changes of individual common stocks. In 1973, I moved to Vermont, where I started and operated an appliance repair business for about six months — an important part of my education. Family problems brought me back to Los Angeles in the fall of 1974, and since then I have been working on the economics of nuclear power, with the goal of improving U.S. policies aimed at limiting the spread of nuclear bombs.

"This thumbnail sketch gives little insight into my intellectual turmoil during these years, when the grand designs derived from objective, scientific analysis were worsening the problems they were supposed to solve: Vietnam, poverty, the Soviet nuclear threat, urban decay, unemployment. The list could go on, but suffice it to say that the failures of these and other analyses were sufficient to cause me to begin a serious quest for better ways to understand the world, a quest that continues to this day."



Mining Earth's Heat: Hot Dry Rock Geothermal Energy

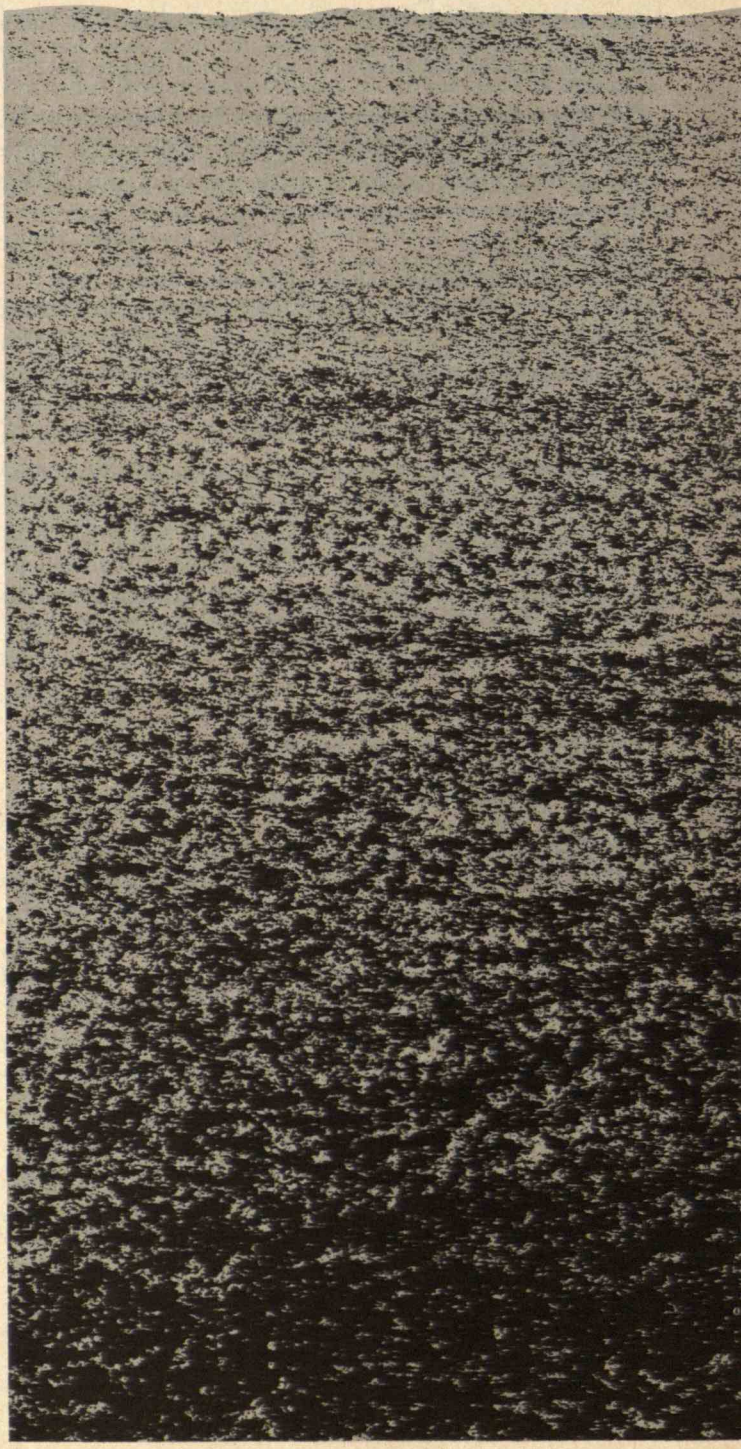
Ronald G. Cummings, Glenn E. Morris, Jefferson W. Tester, and Robert L. Bivins

The energy contained in rock within the earth's crust represents a nearly unlimited energy source. Its inherent inaccessibility has limited its use to only a few sites in the world. At those sites, geothermal power plants utilize drilled wells to bring natural underground hot water and/or steam to the surface; the hot geothermal fluid either flows under artesian pressure or is pumped to a power plant, which may use the fluid to produce electricity, process heat, or both. Often reinjection wells are used to return the cooled fluid to the formation.

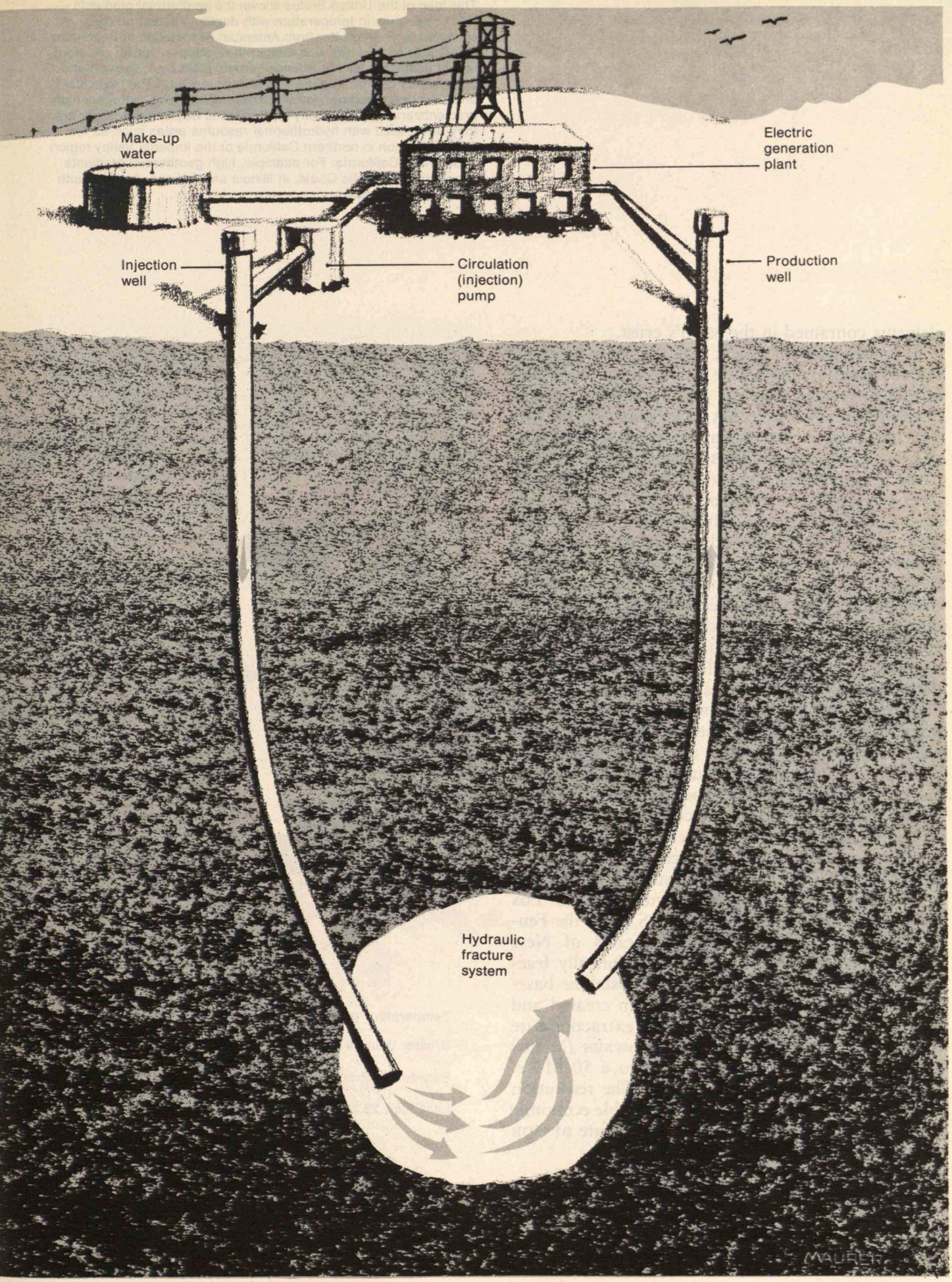
These natural hydrothermal reservoirs represent only a minute fraction of the total energy in place in the hot rock. Exploitation of the remaining fraction involves the development of methods to extract energy from rock formations where this unique combination of geologic and hydrologic conditions does not exist.

Three major heat sources contribute to the hot dry rock resource:

- ☐ igneous related crustal heat from magma bodies;
- ☐ heat transferred by conduction from the earth's interior;
- ☐ heat generated by radioactive decay of certain



Electricity may be generated by an HDR power plant at costs competitive with existing modes of electrical production in many parts of the United States. The elements of such a plant would be likely to follow the general scheme shown. The single fracture indicated is likely to be workable for a reservoir in rock of low permeability, which would tend to retain most of the injected working fluid.


Make-up water
Electric generation plant
Injection well
Circulation (injection) pump
Production well
Hydraulic fracture system
MAURER

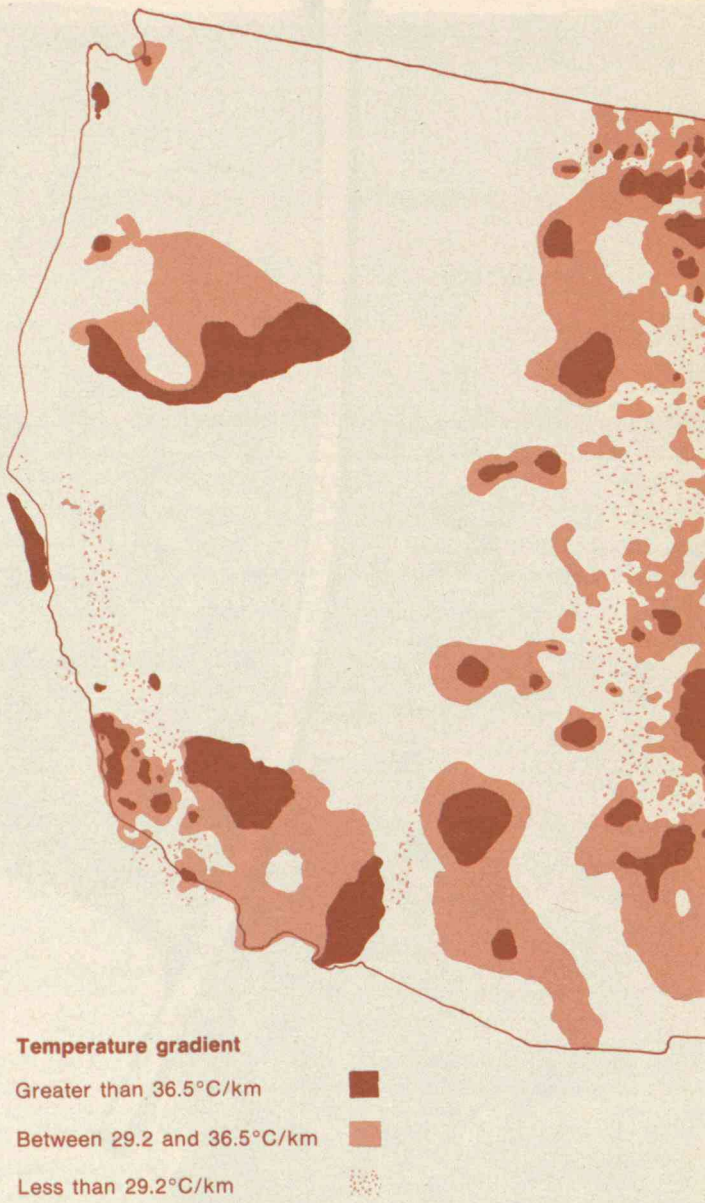
This map of the United States shows the geothermal gradients — rate of increase in temperature with depth — based on data collected by R. M. Potter from American Association of Petroleum Geologists oil and gas well temperature-depth records, and from recent estimates for the Atlantic coastal plain by J. Costain and associates from the Virginia Polytechnic Institute. The large blank areas represent regions for which data are lacking. Note that high gradients are not exclusively located in the western states, nor are they associated with hydrothermal resource areas such as the Geysers region in northern California or the Imperial Valley region of southern California. For example, high geothermal gradients occur on the Atlantic Coast, in Illinois and Indiana, and in South Dakota and Nebraska.

elements contained in the earth's crust.

In some areas of recent volcanic activity, high rates of heat flow may cause visible effects at the surface; for example, erupting geysers and hot springs. In other areas, however, hot rock exists near the surface but there is insufficient water present to produce such phenomena. Thus a potential hot dry rock (HDR) reservoir exists whenever the amount of spontaneously produced geothermal fluid is inadequate for a commercial system. This feature of the HDR resource may provide an advantage in that system temperatures and fluid production rates may be determined by design in contrast to natural hydrothermal reservoirs where these characteristics are determined by prevailing geologic and hydrologic conditions. For example, HDR reservoir temperatures may be selected by drilling to a specified depth determined by the geothermal temperature gradient.

Concepts for creating HDR systems involve drilling holes and connecting them to man-made reservoirs emplaced deep within the crust. In all cases, artificial stimulation is required to create either sufficient permeability or bounded flow paths to allow removal of heat by circulation of a suitable fluid over the surface of the rock.

Many facets related to the technical feasibility of HDR systems have been demonstrated in the first field experiments being conducted by the Los Alamos Scientific Laboratory (L.A.S.L.) at the Fenton Hill site in the Jemez Mountains of New Mexico. At the present time, a hydraulically fractured reservoir in low permeability crystalline basement rock at about 185° C. has been created and flow tested for 75 days at an energy extraction rate of approximately five thermal megawatts (MWt.) Plans are underway to enlarge this to a 50 MWe. capacity with an extended lifetime. The resolution of these technical issues and the inevitable economic trade-offs that exist will determine the fate of HDR as a commercially feasible venture.



Size and Quality of the HDR Resource

Two critical questions confront potential developers of this resource, the responses to which have sig-

nificant impact on the economics of drilling and reservoir development:

☐ How does one precisely define and identify a useful HDR resource?

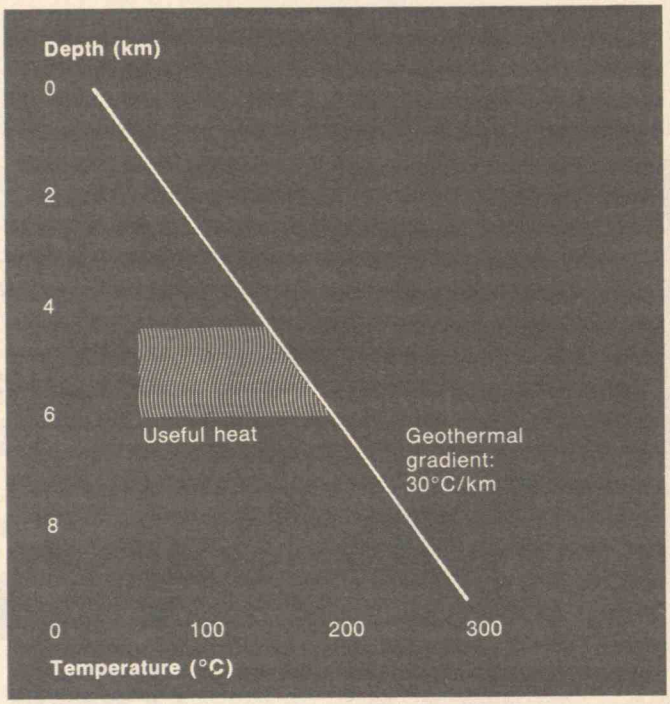
☐ How are HDR resources distributed throughout the United States?

The HDR resource base is generally defined to include crustal rock that is hotter than 150° C. (though for some applications the minimal usable temperature could be as low as 50° C.), is at depths less than ten kilometers, and can be drilled with presently available equipment. While technically feasible, prevailing economic factors will obviously determine commercially feasible depths. Depending on end use, useful rock temperatures may be as low as 100° C. for space heating purposes. However, temperatures greater than 200° C. are desirable for producing electricity.

The HDR resource base is very large. Using a conservative average geothermal temperature gradient of 22° C. per kilometer (km.) of depth, a staggering 13×10^{21} joules (J.) (13,000,000 quadrillion British thermal units, or *quads*) of total energy are calculated to be contained in crustal rock to a ten km. depth in the United States, including Alaska and Hawaii. In comparison, the present annual U.S. energy consumption is approximately 80 quads. The real question remains as to how much of this resource base can be recovered. If we assume that only about 0.2 per cent is technically recoverable, we find a total that is comparable to the estimated resource base of all the coal remaining in the United States.

The geothermal gradient, which determines the depth of drilling required to reach a specified temperature, is a major factor in the recoverability of geothermal resources. There is an obvious trade-off in HDR systems between the temperature required and the depth of drilling necessary to reach it. The problem is to balance the economics of deeper, hotter, more costly wells versus shallower, cooler, less expensive wells against the value of the final product, electricity and/or heat.

Studies by W. H. Diment and his colleagues at the U.S. Geological Survey (U.S.G.S.) show that rock underlying about five per cent of the total U.S. land



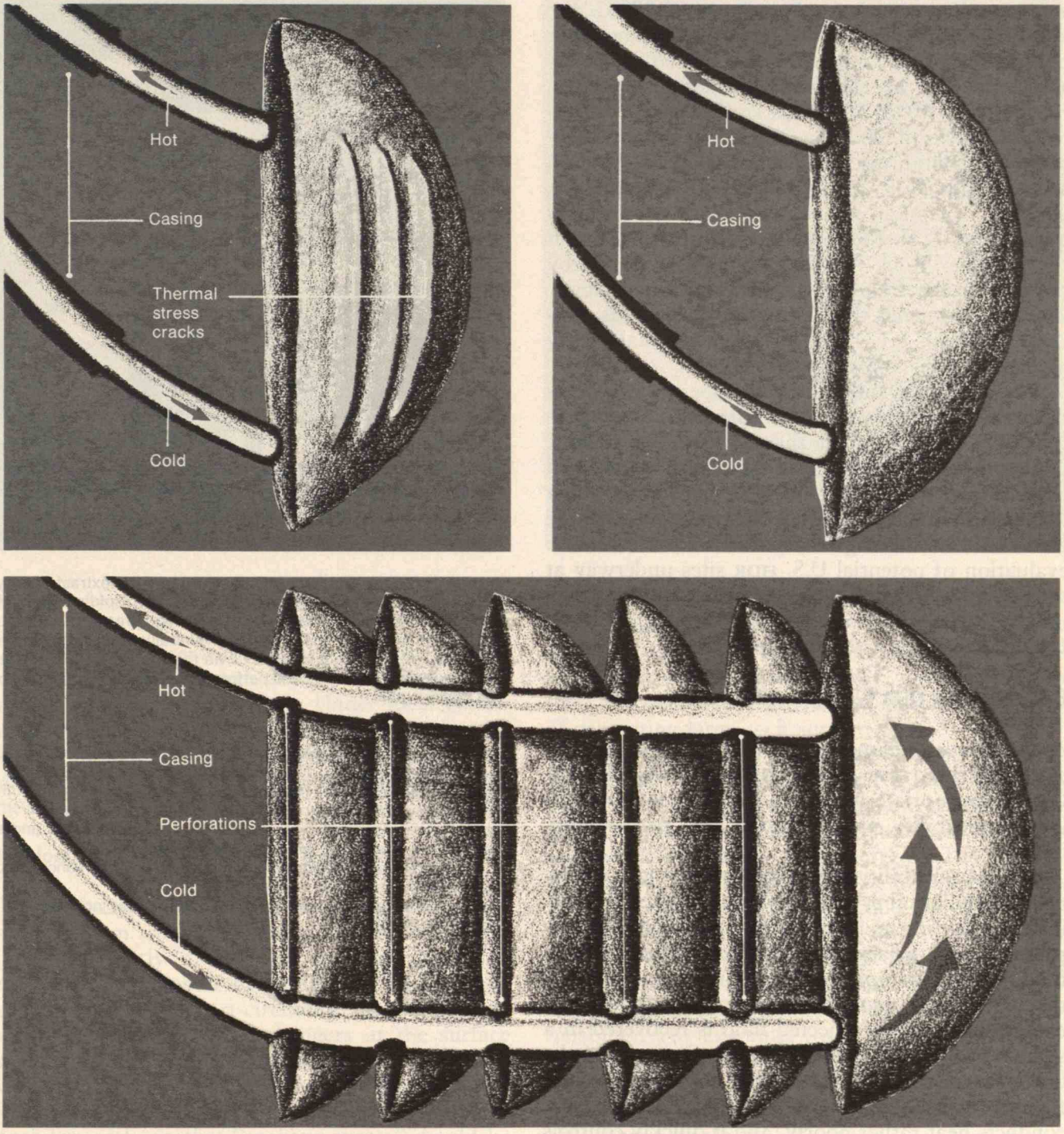
Above: This plot of rock temperature against depth illustrates potentially useful energy contained in an HDR resource. The tinted area denotes the range of heat usable for the commercial generation of electricity in a location with a mean geothermal gradient of 30° C./km. to a minimum useful temperature of 50° C., corresponding to a depth of 4.5 km, is considered. An assumed maximum economic drilling depth of 6 km. then determines the highest reservoir temperature possible, in this case 195° C.

Right: Rock formations with low permeability could produce useful heat by circulating water through "reservoirs" consisting of one or more fractures at appropriate depths.

The first drawing shows a single hydraulic fracture produced by high-pressure fluid injection. After thermal exhaustion of the original fractured zone, a second fracture could be grown from the same borehole. Each fracture would be roughly penny-shaped, 100 m. or more in diameter and a few millimeters wide in cross section.

The second drawing shows the development of the thermal stress cracks that may form during continued operation of an HDR reservoir. Such cracks have the effect of increasing the effective heat transfer surface area available to the circulating fluid.

As suggested by R. M. Potter of L.A.S.L. and C. B. Rayleigh of the U.S.G.S., a possible arrangement of multiple parallel fractures is shown in the third diagram. The fractures would also be grown hydraulically by fluid injection. Perforations in the casing of the lower borehole would be used to regulate the flow of fluid into the fractures.


Hot
Casing
Thermal stress cracks
Cold
Hot
Casing
Cold
Hot
Casing
Perforations
Cold

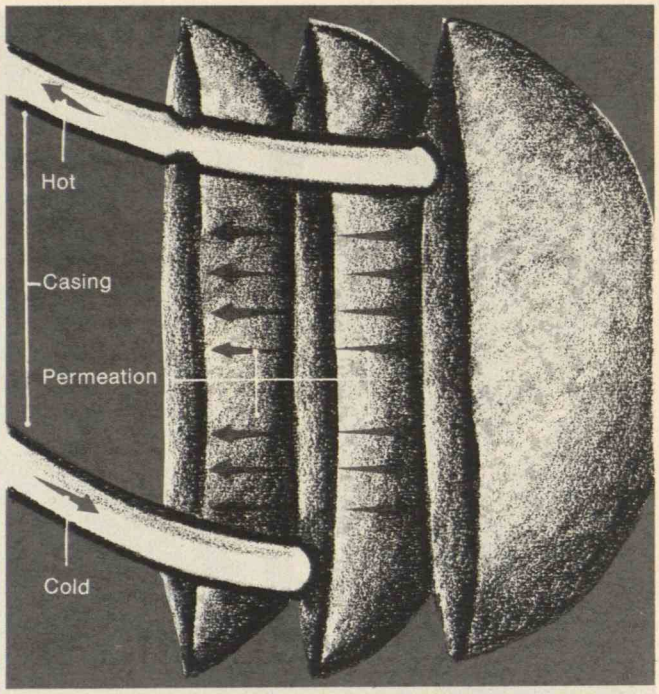
area may have geothermal gradients of 40° C. per km. or more. Conservatively, it can be assumed that over a third of the land area in the United States has above average heat flow with thermal gradients ranging from 30° to 36° C. per km. Igneous rock systems to depths of ten kilometers under the continental United States (not including Alaska and Hawaii) are estimated by R. L. Smith and H. R. Shaw of the U.S.G.S. to contain about 105×11^{21} J. (105,000 quads) and T. R. McGetchin and his associates on the Hot Dry Rock Assessment Panel convened by the U.S. Energy Research and Development Administration estimated that such igneous systems contain 74×10^{21} J. (74,000 quads) of thermal energy at temperatures above 150° C.

Other physical and chemical properties of potential HDR formations are as important to energy extraction feasibility as are the geothermal gradients. Different formation permeabilities, porosities, and chemical reactivities with hot water obviously affect the development of potential HDR reservoirs. These factors are now being incorporated in an extensive evaluation of potential U.S. HDR sites underway at the L.A.S.L. This will be based in part on improvements to the gradient data base provided by the U.S.G.S. resource assessment program.

Extraction of HDR Geothermal Energy

At least two fundamental approaches are now generally accepted for mining HDR geothermal heat. One is appropriate for use in rock formations with low permeability, the other for high permeability rock.

If the permeability of the formation is low, an artificial circulation system can be created by fracturing the rock in the reservoir to provide many flow passages with a large heat-transfer surface area. A fluid — for example, water — is then circulated through the fractured reservoir to recover the energy. Most of the injected fluid is recovered in a second production wellbore simply because of the low natural permeability of the formation. Large fracture surface areas are required because rock conducts heat rather poorly, and it quickly controls

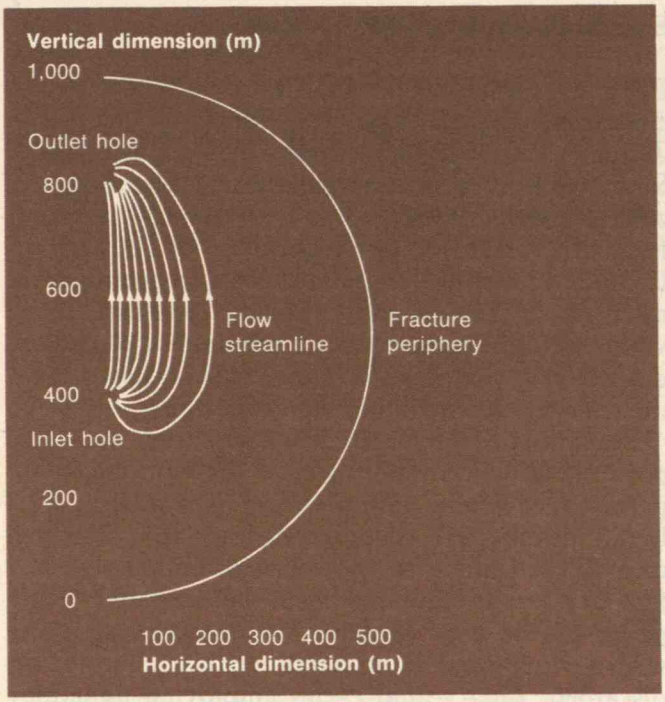


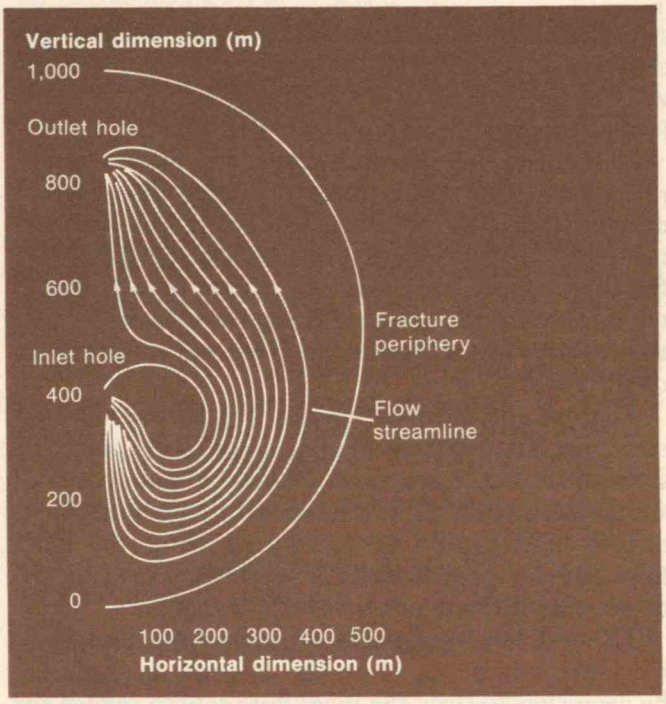
Above: Three parallel fractures could be used to extract energy from rock formations having high permeability. Cold water would be injected into the central fracture under high pressure. The water would then permeate the hot rock, eventually reaching the outer fractures, from which it would exit via the second wellbore. Note how the wellbore casings and perforations force the water to follow the desired path.

Right: These computer simulated flow contours represent the circulation of fluid as heat is transferred to fluid in a single, penny-shaped fracture. The fracture has a radius of 500 m. and a very thin elliptical cross section. The streamlines shown in both diagrams contain approximately 10 per cent of the total 144 kg./sec. flow. An initial mean rock temperature of 250° C. and a geothermal gradient of 50° C./km. were used.

The left diagram indicates the flow of water with buoyancy effects suppressed due to high impedance.

The right diagram shows a similar fracture, but includes buoyancy effects.





the rate of heat transfer to the fluid contained in the fracture zone.

Such an HDR reservoir will most likely be formed by injecting fluid through a wellbore at pressures sufficient to fracture the rock. Under ideal conditions, the fracture would be vertically oriented, circular in shape, with a maximum radius of typically 100 meters (m.) or more, and a width or opening of only a few millimeters.

Problems of Containment and Recovery

The production wellbore in this downhole circulation system should intersect the fractured region sufficiently above the injection point to maximize the exposure of fluid to the fracture surface by avoiding "short-circuiting" and exploiting buoyancy effects. Heat exchangers at the surface would extract energy from the geothermal fluid, which would then be reinjected to complete a closed cycle. Some water would be lost even in low permeability rock, so that "makeup water" would be added. Because the rock has a low thermal conductivity, fractures separated by greater than 50 m. show only negligible thermal interference over a 20 to 30 year period. Consequently, multiple parallel fracture systems may provide an alternative method of generating large rock surface areas.

In formations with high permeabilities, the problem of fluid circulation may be of only secondary importance to that of containing and recovering the geothermal fluid. Water-drive and flooding methods, long used for the underground recovery of gas and oil, may be applicable to high permeability HDR reservoirs; these methods make use of networks of injection and production wells, arranged to minimize fluid loss to permeable rock surrounding the field. Alternatively, injection and production wells could be located to take advantage of the permeability. For example, three parallel fractures of similar area could be created, of which the central fracture would serve as the fluid injection surface and the two flanking fractures would receive fluid that permeates the rock from the central fracture. If

a uniform flow distribution can be maintained through such a system, the lifetime of the reservoir will be determined by the heat content of the rocks in the fractured region.

Obviously, any HDR reservoir will have a finite rate of temperature decline over time. The thermal drawdown, or cooling rate, for a fractured low permeability HDR reservoir depends on the accessible fracture surface area, mass flow rate of water, distribution of fluid across the fractured surface, and the density, heat capacity, and thermal conductivity of the rock.

Thermal drawdown creates a need to develop strategies for reservoir management to optimize the utilization of the resource. From the standpoint of the power producer, the temperature decline of the output fluid should be minimized while the mass flow rate per pair of wells is maximized over the 20 to 40 year lifetime of an HDR power plant.

This will not be possible in the extreme because of the finite area of the reservoir. In some cases it may be necessary to slow the mass flow rate to reduce the rate of temperature decline. Fortunately, substantial enhancement of reservoir performance may occur spontaneously, because as heat is removed from an HDR reservoir, thermal stresses are likely to cause the rock to crack further. Such cracking would provide additional flow channels for the circulating fluid and would enhance the performance and lifetime of the reservoir. Even without thermal stress cracking, thermal contraction of the rock will increase the width of the fracture opening, allowing buoyancy effects to sweep fluid more uniformly over the fracture surface area.

In the absence of thermal stress cracking enhancement, two remedial stimulation alternatives are possible:

- ☐ additional hydraulic fracturing from inclined wellbores by high-pressure fluid injection to produce new surface area in hot sections of the reservoir;
- ☐ sidetracking of the original wellbores to a new region and refracturing to produce a new system.

In addition, multiple fractures grown from inclined boreholes may generate sufficient surface area to prolong reservoir lifetime significantly.

Electric Power from HDR Systems

Using a geothermal resource to supply heat to an electric power generating cycle frequently involves a different set of design criteria from conventional fossil fuel fired or nuclear generating cycles. Because conversion efficiencies range from 8 to 20 per cent for geothermal resource temperatures of 100 to 300° C., and because drilling-related costs frequently represent more than 60 per cent of the total capital investment in the power plant, a premium is placed on designing and operating conversion systems near their thermodynamic limiting efficiencies.

Rankine or similar cycles have been used for power production with water as the working fluid, particularly where natural steam is available. For liquid dominated systems, steam vapor can be created by flashing the geothermal fluid at the surface to a lower pressure. Then, the saturated steam phase can be used to drive a turbogenerator unit, with the unflashed liquid fraction either reinjected or discarded. Binary-fluid cycles employing nonaqueous working fluids are alternatives to single and multiple flashing systems currently in use in various parts of the world (for example Cerro Prieto, Mexico, and Wairakei, New Zealand). Binary-fluid cycles involve a primary heat exchange step where heat from the geothermal fluid is transferred to another working fluid, which expands through a turbogenerator and then passes to a condenser/desuperheater for heat rejection to the environment. The cycle is completed by pumping the fluid up to the maximum cycle operating pressure.

Nonaqueous working fluids with large, low-temperature vapor densities would require smaller turbines than the low-pressure steam turbines employed in flashing systems of the same power output. This is particularly true where heat rejection conditions of 30° C. or less exist. Flashing cycles are, of course, simpler because they do not require a primary heat exchanger.

Seven working fluids in addition to water were examined. Refrigerants R-22 ($CHClF_2$), R-600a (isobutane, i-C_4H_{10}), R-32 (CH_2F_2), R-717 (ammonia, NH_3), RC-318 (C_4F_8), R-114 ($C_2Cl_2F_4$) and

Estimating The Energy Worth of an HDR Reservoir

One approach to estimating HDR reservoir performance makes the assumption that a certain fraction η of the recoverable power could be realized by extraction with a uniform flow of working fluid across the face of an ideal plane fracture. By solving a transient problem of one-dimensional heat conduction from the rock into the fracture face — the recoverable power P(t), in joules per second (J./sec.), for uniform flow can be expressed as follows *(see* McFarland and Murphy *and* Wunder and Murphy *in "Further Reading"):*

$$P(t) = \eta \dot{m}_w C_w (T_i - T_{min}) \operatorname{erf}\left(\sqrt{\frac{(\lambda\rho C)_r}{t}\,\frac{\pi R^2}{\dot{m}_w C_w}}\right)$$

where:

$A = \pi R^2$ = area of one face of the fracture (m^2)
C_w = heat capacity of water = 4200 J./kg. K
C_r = heat capacity of granite = 1000 J./kg. K
$\dot{m}_w$ = water mass flow rate through the fracture (kg./sec.)
R = fracture radius (m)
t = time (sec)
T_i = mean initial rock temperature (° C.)
T_{min} = fluid reinjection temperature (° C.)
erf = error function; for example, erf (z) =

$$\text{error function of } z = \frac{2}{\sqrt{\pi}} \int_0^z e^{-x^2} dx$$

λ_r = thermal conductivity of granite = 3.0 W./mK.
ρ_r = rock density ≈ 2,500 kg./m^3

McFarland and Murphy compared P(t) to estimated values that could result from nonuniform flow across the accessible fracture area. Fluid buoyancy and convection effects within an ideal fracture as well as transient conduction of heat through the surrounding rock are treated in a numerical solution of four coupled two-dimensional, nonlinear, partial differential equations describing continuity, fluid momentum, and rock and fluid energy balances. Depending on the location and separation of fluid injection and recovery points within the fracture and the internal fracture permeability (gap width versus radius), the recovered fraction of power η may vary from 0.4 to 0.9 depending on the degree of buoyant circulation through the fracture.

The equation shows that the relative power [P(t)/ P(t=0)] depends directly on the error function of:

$$\left[K\,\frac{R^2}{\dot{m}_w\sqrt{t}}\right]$$

for constant rock and fluid properties, where

$$K = \pi\sqrt{\frac{(\lambda\rho C)_r}{C_w^2}}$$

Thus, predictions of reservoir lifetime can be made for specified ideal fracture sizes and flow rates.

For cases where large stable fractures cannot be produced, smaller multiple parallel fractures may be used to generate the required surface area to maintain an acceptable reservoir lifetime. Wunder and Murphy and Gringarten, et al. have examined the heat extraction capacity of such multiple fracture systems to determine the effects of variable fracture number and spacing. Because of the low thermal conductivity of granite, the thermal drawdown will resemble that for a single fracture as shown in the graph below if fractures are spaced 50 m. or more apart. Wunder and Murphy also treat an intermediate case with 1 m. spacing between fractures where there is a strong superposition of heat flow between fractures and a very different drawdown behavior. In the extreme case of completely rubblized rock, a square temperature wave would propagate through the reservoir, showing a breakthrough effect similar to that anticipated for water-drive type systems. In this case, the lifetime $\bar{\tau}$ of the reservoir would be given by:

$$\bar{\tau} = \frac{\rho_r C_r AL\left\{(1-\theta) + \dfrac{\rho_w C_w}{\rho_r C_r}\,\theta\right\}}{\dot{m}_w C_w}$$

where:
L = separation distance between fractures (m)
θ = porosity

In addition, Harlow and Pracht, using a simplified model, showed that substantial enhancement of reservoir performance could be anticipated because of thermal stress cracking, the fracturing of reservoir rock by temperature-induced stresses. Such thermal stress cracking is not well understood even under well-defined laboratory conditions. L.A.S.L. will use its reservoir at the Fenton Hill field test site to identify *in situ* thermal stress effects. Theoretical work on thermal stress cracking, continued over the past years at Northwestern University by S. Nemat-Nasser, L. M. Keer and associates, and at L.A.S.L. by H. D. Murphy, D. W. Brown and others, has produced new ideas. It is hoped that the extraction of heat from fractured HDR reservoirs may introduce secondary thermal cracks, which will be wide enough to permit convective circulation of fluid; this enhanced circulation will greatly increase the heat removal rate, accelerating the propagation of the cracks, and producing an "autocatalytic" effect. Eventually, another set of orthogonal cracks may form along the surface of the first set of deep cracks, enhancing further the performance of the reservoir. Accurate knowledge of *in situ* reservoir heterogeneities and stresses will be required in order to predict the required cooling for crack initiation and the resulting growth rates of this series of thermal cracks. — *R.G.C., G.E.M., J.W.T., and R.L.B.* □

R-115 (C_2ClF_5) were selected because they provided a range of critical temperatures and pressures, and molecular weights. All of these compounds have relatively high vapor densities compared to water at temperatures as low as 20° C.

Detailed calculations of binary-fluid Rankine cycle configurations were performed to examine the effects of cycle operating pressure, heat rejection temperature, temperature differences in the primary heat exchanger and condenser, turbine and pump efficiencies, and fluid temperature. In each case a utilization efficiency η_u was determined which related the actual electrical work produced by the cycle to the maximum work (or availability) possible with specified geothermal source and heat rejection temperatures. Comparisons were also made with single and multistage steam flashing cycles.

For any given working fluid, there is an optimum set of operating conditions yielding a maximum utilization efficiency for particular geothermal fluid and heat rejection temperatures and turbine and pump efficiencies. In screening potential working fluids, some knowledge of the magnitude of the utilization efficiency and how it changes would be useful. Computer optimizations for the seven working fluids studied were conducted for geothermal fluid temperatures ranging from 100 to 300° C. One observes a characteristic maximum efficiency at a particular resource temperature, which is different for each fluid but generally in the range of 60 to 70 per cent assuming an approach (pinch point) temperature difference of 10° C. between the countercurrently flowing geothermal and cycle working fluids in the primary heat exchanger, an 85 per cent dry turbine stage efficiency, and an 80 per cent feed pump efficiency.

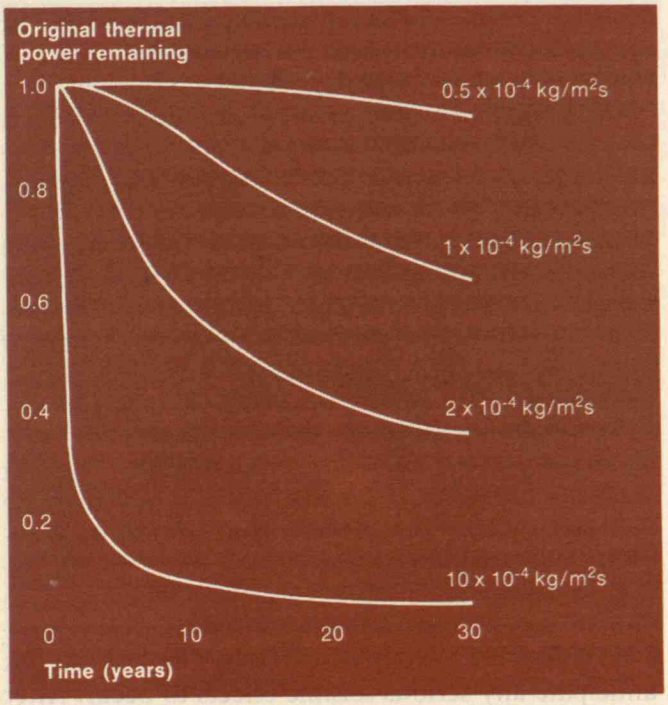
Component efficiencies of this magnitude have been achieved in units of 50 megawatts of electrical output (MWe.) or greater capacity. However, binary-fluid turbogenerators have not as yet been placed in commercial geothermal operation with units of greater than about one MWe. capacity even though smaller units have been operated. Power generation from geothermal, solar, as well as waste heat sources using nonaqueous working fluids will continue to evolve in the coming years under private and public support, and it is not anticipated that any serious problems will exist in scaling-up from the existing 60 kWe. to 1 MWe. units currently available.

The selection of optimum plant design conditions becomes more complex as reservoir temperature declines. Performance is severely curtailed when the plant operates below the wellhead or reservoir temperatures for which it was designed.

A geothermal power plant is very sensitive to changes in conditions for heat rejection. H. E. Khalifa of Brown University estimates that the power output from a geothermal plant would vary by ±32 per cent with fluctuations of ±15° C. in ambient temperature. S. L. Milora and J. W. Tester note a similar effect; their calculations show that with a 200° C. liquid resource, a decrease in condensing temperature from 49° to 27° C. increases the potentially available work by as much as 40 per cent. Thus, because of the inherently low efficiency of geothermal cycles operating with wellhead temperatures below 300° C., a premium is placed on optimizing cycle performance by utilizing lower ambient temperatures when and where environmental conditions permit.

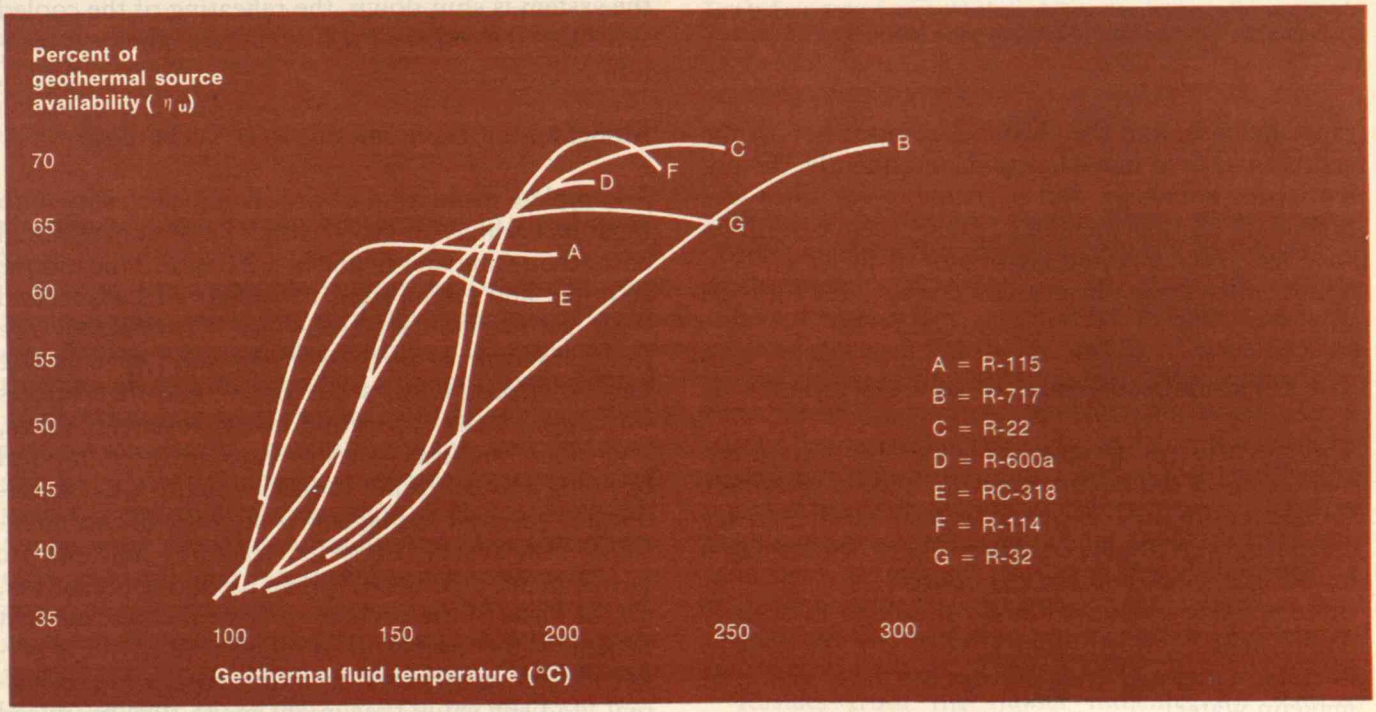
To increase efficiency, pressure losses throughout the system must be minimized, as they will affect pumping requirements and therefore costs. These losses are caused by friction in piping, well casing, or within the fracture itself, and by form drag losses at the entrance and exit regions of the fracture in each wellbore. Based on our experience at the L.A.S.L. Fenton Hill test site, the impedance within the fracture system itself and at the entrance and exit regions will probably produce the largest pressure losses. While such fracture system pressure losses are wholly controlled by the complexity of formation characteristics, other losses can be minimized. For example, friction in piping can be reduced by increasing piping diameters. And pressure losses can be partly offset by the net gain in buoyancy between the cold injection and hot recovery wellbores.

As a wellbore is deepened and reservoir temperatures rise, downhole mineral solubility and reaction



Left: The four curves show different power drawdown (cooling) rates for a hypothetical geothermal reservoir consisting of a single fracture in granite. The greater the ratio of the flow rate divided by the fracture surface area the more rapidly the reservoir cools down. No thermal stress cracking is assumed in the model.

Refrigerants having greater vapor densities than water at low temperatures could be used to power smaller turbines than are required in steam systems, and have comparable or higher overall utilization efficiencies for geothermal fluid temperatures of 100 to 300° C. Seven refrigerants were analyzed to determine operating conditions under which they were thermodynamically most efficient for a specified geothermal temperature. (For details see Milora and Tester, *Geothermal Energy As a Source of Electric Power,* M.I.T. Press, Cambridge, Mass., 1976.)



Base Case Conditions
Life of the system = 30 years
Length of time in a decision period = 5 years
Electric plant capacity = 50 MW(e).
Radius per fracture = 300 m.
Maximum well flow rate ($\dot{m}$) = 75 kg./sec.
Fractures per pair of wells = 12
Horizontal fracture spacing = 50 m.
Geothermal gradient = 40° C./km.
Busbar price of electricity = 3 cents/kWh.
Real cost of equity capital = 6% (12% nominal)
Real cost of debt capital = 3% (9% nominal)
Operation and maintenance costs = 0.13 cents/kWh.
Revenue tax = 0.07 cents/kWh. (2.5% of busbar price)
Joint federal and state income tax rate = 51%

These are the base-case parameter values used in the optimization model to evalute hot dry rock (HDR) energy for the production of electricity. The number of fractures were selected to assure that reservoir temperature drawdown does not significantly affect system efficiency; this is equivalent to assuming that sufficient heat transfer area existed to maintain geothermal fluid temperatures within ten per cent of their original design value through the thirty-year lifetime projected for such a plant. Capital costs are referred to as "real" because they are exclusive of the investors' anticipated rate of general price inflation.

rates increase, and the chemical composition of the geothermal fluid may change. Consequently, the potential for corrosion and particularly for silica and carbonate scaling increases. These chemical effects vary with each site and formation so that their economic impact must be evaluated separately for each case.

The Environmental Impact of HDR Operation

The operation of an HDR system should have minimal effect on the environment for several reasons:

☐ The entire fuel cycle is located at the power generating station, in contrast to energy cycles based on oil, gas, coal, and nuclear sources.

☐ Liquid and gaseous effluents should be essentially nonexistent for HDR systems, which are intended to operate in a closed cycle (except for the injection of makeup water).

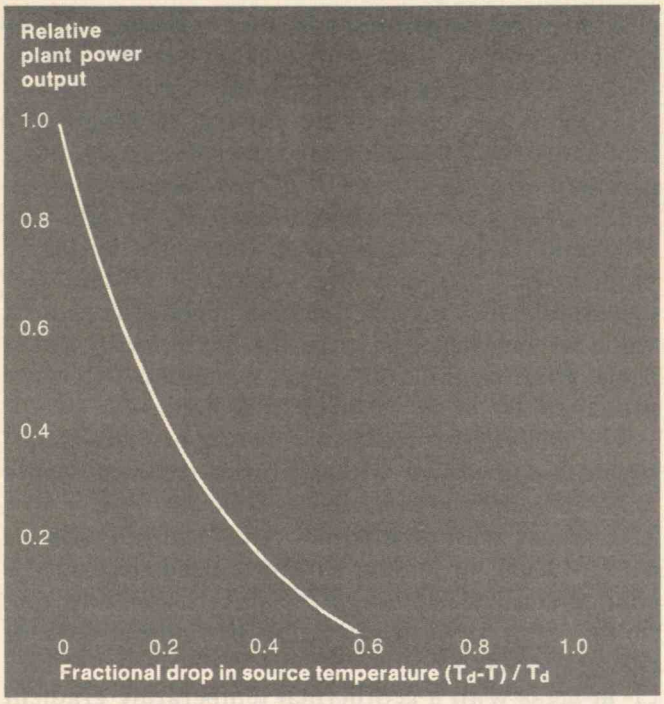
☐ If water chemistry problems such as corrosion or scaling exist, some treatment may be required and solid effluents (removed deposits) may result. But these should not present a serious environmental impact; for example, a 100 MWe. plant might produce 1 to 10 tons per day of silica or calcium carbonate material.

☐ Although water loss through permeation in the reservoir formation may be a strong economic factor, particularly in arid regions, aquifer contamination is highly unlikely due to the extreme depths of postulated HDR fracture systems — typically 3 to 5 km.

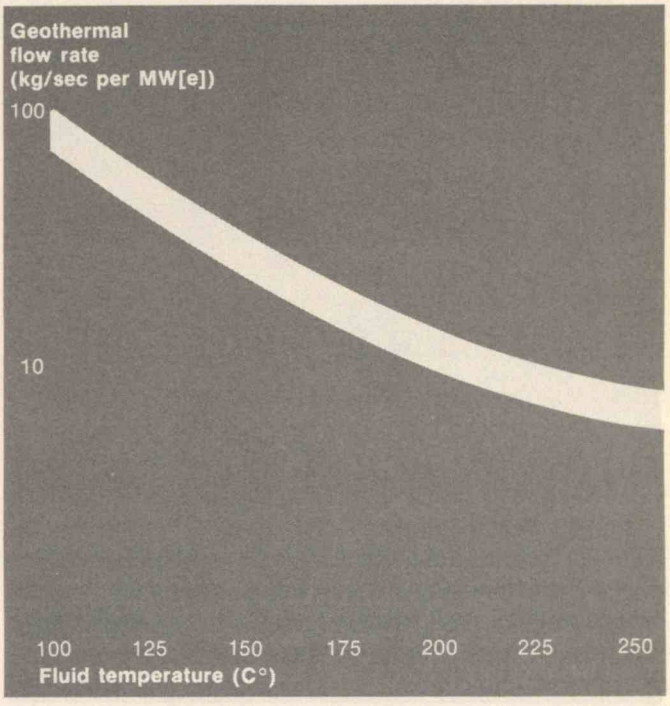
The major environmental concern with HDR systems is seismicity induced by injected fluids. The first extensive test at the L.A.S.L. Fenton Hill test site failed to produce any seismic events (threshold Richter 0.5) that could be detected by surface seismic arrays that surrounded the experiment. The propagation of thermal cracks in rock of this type in a large earth stress field is inherently stable, and we do not anticipate any serious seismic effects to occur. After the system is shut down, the reheating of the cooled section of the reservoir will occur in a quiescent fashion.

Modeling the Economics of HDR Technology

A complete evaluation of producing electricity with HDR technology must include both conventional cost accounting and financial aspects and the unique resource and engineering considerations associated with geothermal systems. *(See "Estimating the Energy Worth of an HDR Reservoir," p. 67.)* We have incorporated these factors — and their effects on capital costs, operating costs, revenues, taxes, and other financial issues — into an intertemporal optimization computer model, which is used to determine the best management strategy for an integrated HDR system of wells, fractures and electric power plant. The model is then used to demonstrate, on the basis of the present value of net benefits (net benefits after taxes and minimal profits) the reservoir design, geothermal well flow rate, and geothermal gradient value that might make HDR-produced



The power output of an HDR geothermal generating plant declines as the reservoir temperature drops below the design temperature. This graph illustrates the decline, plotted against "fractional source temperature drop," which is the difference between design temperature and actual temperature divided by design temperature.



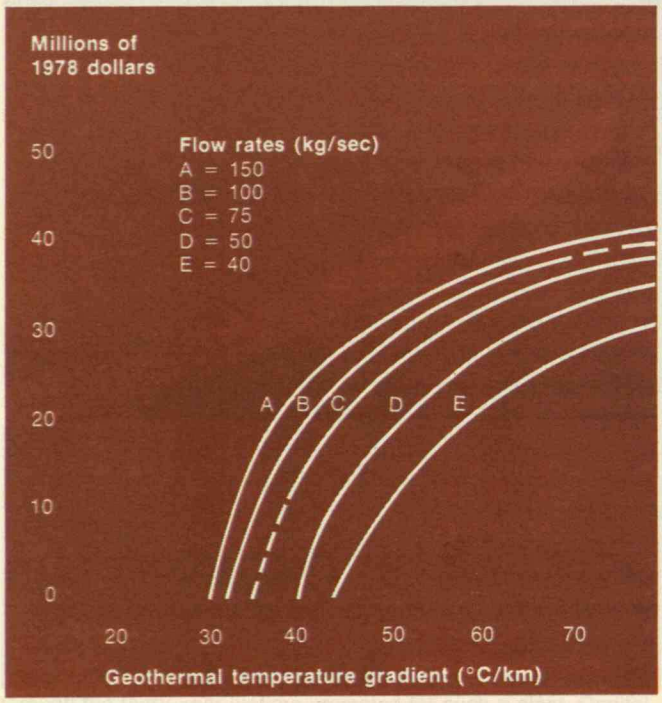
To produce a given amount of electric power, less geothermal fluid is required as the reservoir temperature increases.

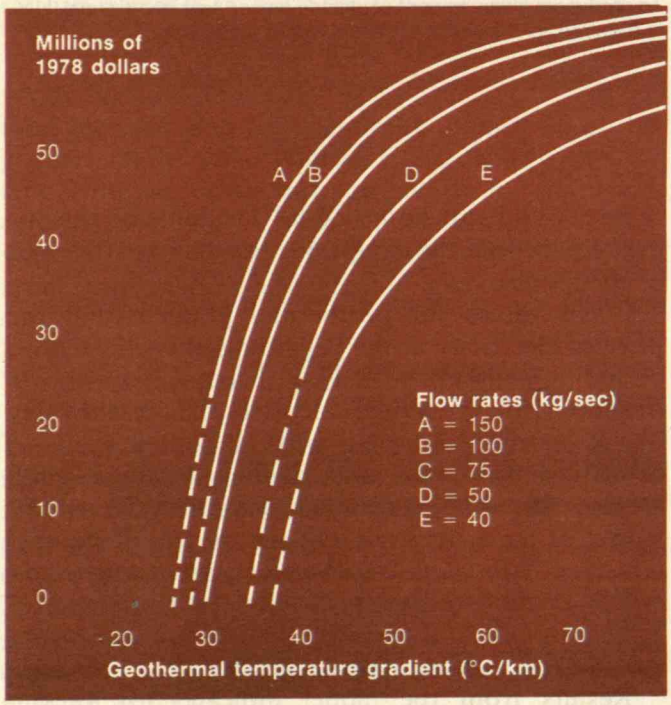
electricity commercially competitive in the United States.

Among the variables subject to control in the model are the operating well flow rate, initial drilling depths, and periodic redrilling. Parameters in the model include installed capacity, geothermal gradient, design temperature and design well flow rate for the electric generating plant, and reservoir size (which for the purpose of this paper is varied with the design well flow rate to insure negligible temperature drawdown simultaneously). The effects of design well flow rate and geothermal gradient on costs were examined. Various economic considerations are also specified, for example, a thirty year plant life is assumed and a selling price for electricity at the busbar is set alternatively at three or four cents per kilowatt-hour (kWh.) The table on the opposite page lists the conditions for the base case run of the model.

Given values for geothermal gradient and the price of electricity at the beginning of each decision period (a "decision period" in this case is a five year time interval), the model calculates the present value of net benefits associated with all combinations of operating flow rate and drilling strategies and chooses the combination that maximizes the present values of these net benefits over the life of the system. *(See "Modeling Geothermal Opportunities" on p. 73; a complete specification of this dynamic programming model is given by the authors in an internal L.A.S.L. report, August, 1978.)*

Results from the model indicate, for various





combinations of parameter values, whether the optimally managed HDR plant is commercially attractive or not. For example, with electricity priced at three cents per kWh. at the busbar, a design well flow rate of 40 kilograms per second (kg./sec.), and a geothermal gradient of 40° C. per kilometer (° C./km.), an HDR electric generating facility might lose $9.2 million over its lifetime. But with that same gradient and well flow rates between 50 and 105 kg/sec (all other parameters unchanged) the present value of net benefits from the investment would range from $1 million to $22.8 million. All costs presented are in constant 1978 dollars.

The analysis for reservoirs having negligible temperature drawdown with all other technical issues resolved can be generalized as follows:

☐ In areas with geothermal temperature gradients of 50° C./km. or higher, HDR-produced electricity is commercially feasible *regardless* of the well flow rate (in the range of 40 to 150 kg./sec.) at busbar costs of three cents/kWh.

☐ In areas with a geothermal temperature gradient of 40° C./km., a well flow rate of 40 kg./sec. would require a busbar cost greater than three cents/kWh. for a positive present value of net benefits; however, with flow rates in the range of 50 to 150 kg./sec., HDR-produced electricity would be commercially feasible with busbar costs of three cents/kWh.

☐ In areas with gradients between 20° and 30° C./km., HDR-produced electricity would result in busbar costs that are higher (most likely, *much* higher) than three cents/ kWh. for all well flow rates in the range of 40 to 150 kg./ sec.

☐ In areas with gradients of 40° C./km. or higher, HDR-produced electricity would be commercially competitive at busbar costs of four cents/kWh. for all flow rates.

As the temperature gradient increases, shallower, less expensive wells are required. Consequently, at various design flow rates, the net financial benefits of a typical plant would improve with increasing geothermal gradients. At the top is shown the present value of net benefits of an optimally managed HDR system for a range of geothermal temperature gradients and various design flow rates, assuming a busbar price of three cents; at the bottom is shown the present value of net benefits when the busbar price is four cents/kWh. These figures were generated by an intertemporal computer optimization model developed by the authors.

□ Where gradients of 30° C./km. are available and at flow rates of 75 kg./sec. or more. HDR generation is economically feasible with busbar costs at or above four cents/kWh.

An additional perspective for the relative costs of HDR-produced electricity may be obtained as follows. For a 50 MWe. plant in areas with a 50° C./km. gradient, the present value of total capital costs (wells and power plant) range from $2130/kWe. to $1560/kWe. as the maximum well flow rate varies from 40 kg./sec. to 150 kg./sec. Other economic analyses for hydrothermal systems have shown similar ranges of capital costs for wells and power plants. This compares with plant costs (not including fuel) of $500 to $700/kW. for coal and $1000/ kW. or more for nuclear plants now under construction in the United States. In HDR systems, one then accepts higher initial investment costs in return for lower future fuel costs relative to more conventional technologies.

As an alternative approach to describing feasibility, consider that for a given set of resource and reservoir conditions, including type of formation, geothermal gradient, fracture size, and design flow rate, there exists an optimal management strategy of drilling, redrilling, and plant operation that will result in a minimum "breakeven" price. This breakeven price would generate revenues just sufficient to cover all costs, including taxes and returns to investors and lenders at specified real rates. The graph on p. 74 presents this breakeven price as a function of geothermal gradient and design well flow rate, assuming negligible temperature drawdown. At higher gradients and flow rates, a busbar price of *less than two cents/kWh.* is sufficient to earn the six per cent real rate of return which was specified in the model.

Referring to the lower figure on p. 74, the minimum breakeven price of HDR-produced electricity described above is very sensitive to the assumed real rate of return. As real rates of return for equity and debt increase from the 6 per cent/3 per cent used in the base case rise to 17 per cent/6 per cent, the breakeven price rises from 2 cents/kWh. to around 5.5 cents/kWh.

Finally, it is interesting to note the effect of the

Modeling Geothermal Opportunities

The model employed in this research requires as input basic information about the HDR system under consideration. It then determines the optimal time path of management decisions for this system, where optimal is defined as that management strategy which maximizes Φ, the present value of net benefits where net benefits are defined as net revenues after taxes and minimal profit. This objective is expressed mathematically as:

$$\text{Maximize } \phi = \sum_{n=1}^{N}\left[\sum_{t=1}^{\tau}(R_{n,t})\,(1+r)^{-t}\right]$$

$$-\left\{C_s + \sum_{n=1}^{N} C_d(1+r)^{-\tau(n-1)} + .51\right.$$

$$\left[\sum_{n=1}^{N} C_d(1+r)^{-\tau(n-1)} - \frac{C_d}{(1+r)^{\tau N}}\right]$$

$$\left. - .51\,C_s\left[\frac{(1+i)^{\tau N}}{(1+r)^{\tau N}} - \frac{1}{(1+r)^{\tau N}}\right]\right\} \quad \text{where:}$$

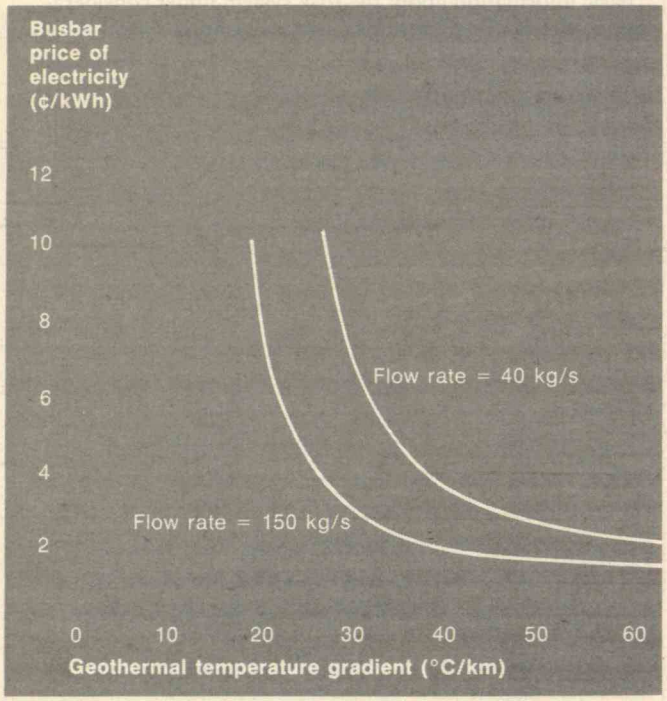
N = the number of decision periods over the assumed life of the HDR system
τ = the number of years in a decision period
r = the opportunity cost of capital (real rate of return)
i = the real debt rate of interest
$R_{n,t}$ = revenues net of revenue tax and operating cost for the t^{th} year of the n^{th} decision period (1978 dollars)
C_s = surface plant costs (1978 dollars) discounted to present value at year 0 (start of plant operation)
C_d = drilling costs (1978 dollars)

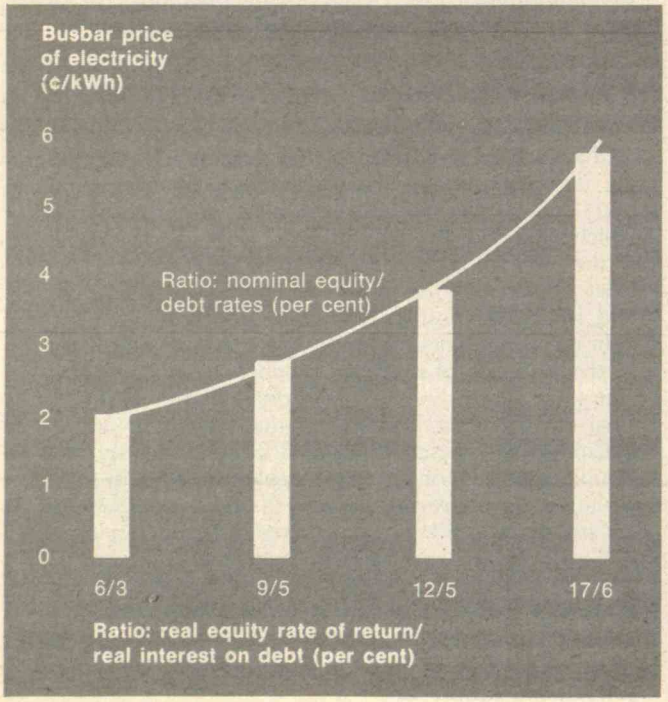
This equation is structured so that the system is examined at each decision period. After systematically exploring the ramifications of each management option for every state of the system, the model selects that option which maximizes the objective function. By doing this for all decision periods over the life of the system, it arrives at a determination of the optimal time path of such decisions and, hence, the most economic way of operating.

In this formulation, revenues and costs are discounted to the beginning of electricity production or plant operation ("the present") by an appropriate discount rate and then the difference between revenues and total costs is calculated. The present discounted value of revenues is the double summed term just to the right of the equality in the equation. The present discounted value of costs (in braces) is composed of separate terms for surface costs, drilling costs, income taxes on equity, and income tax *credits* on interest payments to debt holders. As implemented in the model, however, the composition of the terms presented in the equation is more elaborate than this description alone suggests. — *R.G.C., G.E.M., J.W.T., and R.L.B.* □

Top chart:
The busbar price of electricity is critical in determining the profitability of an HDR power plant. Assuming the temperature drawdown of the reservoir is negligible over the lifetime of the plant, the commercial operation would break even financially along the two curves shown in the graph. The higher curve represents a design flow rate of 40 kg./sec.; the lower curve, 150 kg./sec. At higher geothermal gradients, both flow rates could yield profits with a busbar price under three cents/kWh.

Bottom chart:
The sensitivity of busbar price to differing equity rates of return and debt rate of interest under base case conditions is shown. Nominal rates of return and interest were computed by adding the estimated rate of general price inflation to these real value rates.





geothermal gradient on the optimal drilling depth and the associated drilling costs. As one would expect, the higher the geothermal gradient, the shallower is the optimal drilling depth. In fact, drilling costs decline more than in proportion to the increase in geothermal gradient. For example, total drilling costs per pair of wells, excluding surface piping and contingency factors, fall from $4.7 million in a 30° C./km. gradient area to $1.1 million in a 60° C./km. gradient area — a doubling of the gradient results in a 76 per cent decline in total drilling costs.

Conclusion: "Guarded Optimism"

As is usual with a technology in a relatively infant stage, definitive statements concerning feasibility must await further development and demonstration. It is encouraging at this point, however, to see that electricity production from HDR resources would seem to be commercially competitive in numerous areas of the United States using economic and reservoir parameter values which, at least at this point, seem "reasonable" to many involved engineers and economists. There are no simple answers and each issue must be treated in detail before the question of commercial feasibility for HDR can be settled.

The analytical results presented in this article are based on a very limiting set of assumptions as to HDR reservoir parameters and designs. Clearly, considerably more experimental and economic research is required before a definitive assessment of the commercial feasibility of HDR-produced electricity can be made. Within this limited context, however, the results provided here suggest grounds for at least guarded optimism as to the possible feasibility of HDR-produced electricity in areas of the United States with temperature gradients in the 40-plus °C./km. range and where "competitive" busbar costs are approximately three cents/kWh. or higher.

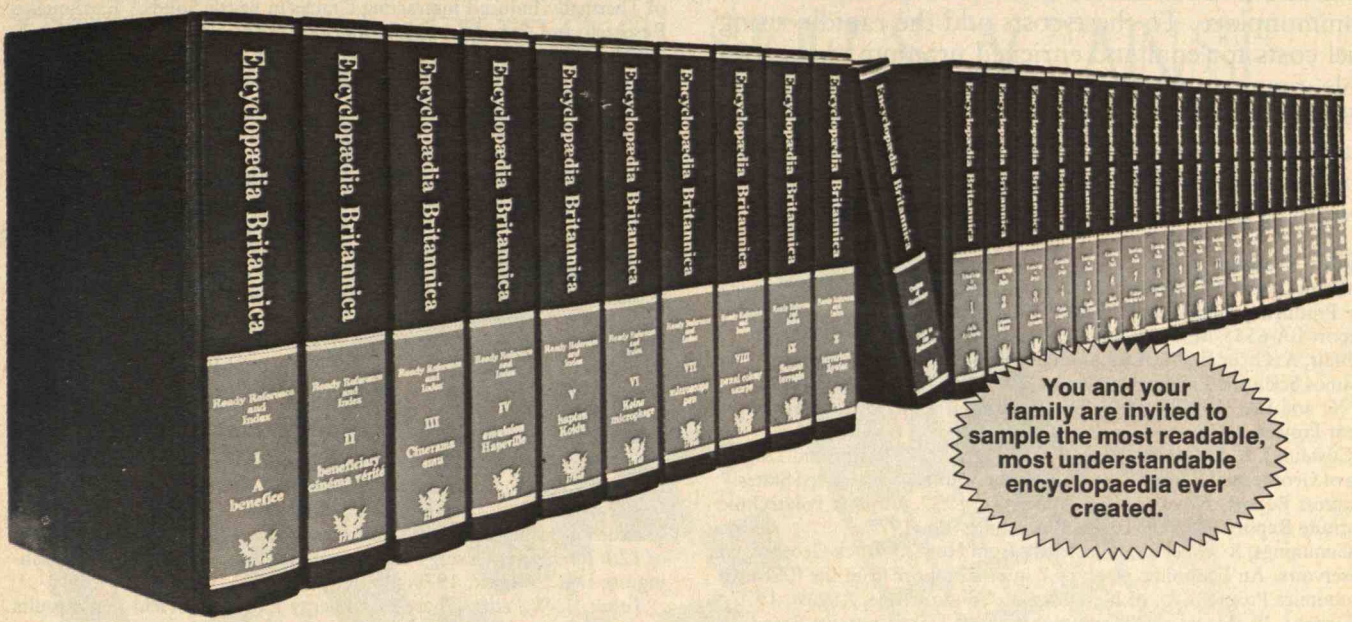
Variations in the reservoir design and operating parameter values as well as financial and regulatory criteria used in this paper could markedly influence the potential competitiveness of HDR-produced electricity. As examples, abnormally high plant costs (caused by poor geofluid quality), higher discount (interest) rates, and particularly, increased rates of temperature drawdown or reservoir water losses would decrease the relative attractiveness of HDR-produced electricity. However, advances in drilling technology, lower taxes (via depletion type allowances) and allowing deductions for intangible drilling expenses, investment tax credits, and perhaps system design to accommodate cogeneration or process heat plants might well extend the commercial feasibility of HDR to lower gradient areas.

Certainly another factor that will control the rate of commercial development of HDR, or for that matter all geothermal development, is the current cost and availability of busbar power from more con-

A substantial GROUP DISCOUNT

FOR TECHNOLOGY REVIEW SUBSCRIBERS

introducing a revolutionary new 3-part *Home Learning Center*



THE *new* ENCYCLOPAEDIA BRITANNICA

now available to you Direct-From-The-Publisher at a substantial group discount!

Easier to read . . . Easier to understand . . . *Designed to be used!*

For over 200 years Encyclopaedia Britannica has been recognized as the reference standard of the world. Now . . . the world's most authoritative and complete reference work has been redesigned and totally rewritten to bring your family a far more readable, usable, informative encyclopaedia than ever before available. And it can be yours at a substantial group discount. You can receive the complete 30 volume set at once, but pay later on convenient credit terms. It's the easiest way ever to own this revolutionary new Home Learning Center.

More useful, in more ways, to more people—
Now arranged for 3 reasons into 3 parts.

In a dramatic 3-part arrangement that makes seeking, finding and knowing easier than ever, THE NEW ENCYCLOPAEDIA BRITANNICA provides quick facts clearly and concisely for the school-age child, and at the same time can motivate student and adult alike into the magical world of self-enrichment.

1. TO GET AT THE FACTS QUICKLY AND EASILY. This need is served by the 10-volume *Ready Reference and Index* which contains 102,000 right-to-the-point articles so readable that never before has Britannica been as useful and valuable in homework assignments.

2. TO DISCOVER THE *MEANING* OF THE FACTS. This need is served by the 19 *Knowledge In Depth* volumes containing 4,200 articles providing understanding and insight to make the facts come alive with meaning.

3. *TO EXPLORE* ENTIRE FIELDS OF KNOWLEDGE. This need is served by the revolutionary one-volume *Outline and Guide* which is a readable guide to the whole of human knowledge.

Together, the three parts of THE NEW ENCYCLOPAEDIA BRITANNICA combine to achieve a breakthrough in publishing history and result in a family reference of extraordinary and unequalled usefulness.

Mail Card Now . . . for special, new Preview Booklet

May we send you, free and without obligation, our new Preview Booklet which pictures and describes THE NEW ENCYCLOPAEDIA BRITANNICA in detail. This will let us know of your interest and enable us to contact you to see if you want further details on THE NEW ENCYCLOPAEDIA BRITANNICA. We'll also give complete information on this exciting group discount which automatically includes a full 10-year membership in the Britannica Library Research Service.

Fill out postage-free card and mail TODAY!

Easier to use . . . Britannica 3 is totally redesigned to let you find facts fast . . . then go as deeply as you want into virtually any subject!

Easier to read . . . Britannica 3 has been completely rewritten so even a child can read and learn from it, while adults will read it for sheer pleasure!

Easier to understand . . . Britannica 3 has been written for *today's reader,* in *today's language,* so that its wealth of information is easier to absorb than ever before!

INCLUDED AUTOMATICALLY

Britannica's Library Research Service

—a full 10-year membership in the Britannica Library Research Service brings you up to 100 research reports on almost any subject—professionally prepared at Britannica's expense!

ventional sources such as coal and nuclear fission. In many cases, due partly to environmental and regulatory restrictions, coal-fired and nuclear plant costs have escalated to a point where $500–700/kW. for coal and $1000/kW. or more for nuclear are now commonplace. To these costs add the rapidly rising fuel costs for coal and enriched uranium. A reasonable range for busbar prices for new capacity in 1985–90 might be from 3 to 6 cents/kWh. (in constant 1978 dollars). If busbar costs are at the high end, a considerable incentive for HDR development would exist.

Further Readings

Altseimer, J. H., "Technical and Cost Analysis of Rock-Melting Systems for Producing Geothermal Wells," Los Alamos Scientific Laboratory Report LA-6555-MS, Los Alamos, N.M., November, 1976.

Blair, A. G., et al., "L.A.S.L. Hot Dry Rock Geothermal Project," Los Alamos Scientific Laboratory Report, LA-6525-PR, Los Alamos, N.M., 1976, and LA-7109-PR, "Hot Dry Rock Geothermal Energy Development Project, 1978.

Costain, J. K. L. Grover, III, and A. K. Sinha, "Evaluation and Targeting of Geothermal Energy Reservoirs in the Southeastern United States," Progress Report, Nov. 1, 1976–March 31, 1977, Virginia Polytechnic Institute Report VPI-SU-5103-3, Blacksburg, Va. 1977.

Cummings, R. G., et al., "Electricity from Hot Dry Rock Geothermal Reservoirs: An Economic Analysis," internal report from the Resource Economics Program, U. of New Mexico, Albuquerque, August, 1977.

Diment, W. H., et al., "Temperatures and Heat Contents Based on Conductive Transport of Heat," in "Assessment of Geothermal Resources of the United States–1975," *U.S. Geological Survey Circular 726,* Reston, Va. 1975.

Energy Research and Development Administration Report ERDA-76-1, "National Plan for Energy Research, Development, and Demonstration," U.S. Government Printing Office, Washington, D.C., 1976.

Eskesen, J. H., "Cost and Performance Comparison of Flash Binary and Steam Turbine Cycles for the Imperial Valley," in *Proceedings of 12th Intersociety Energy Conversion Engineering Conference,* Washington, D.C., August, 1978, Vol. 1, p. 842.

Grieder, R., "Economic Considerations of Geothermal Exploration in the Western United States," presented at the Symposium of the Colorado Department of Natural Resources, Denver, Colo., Dec. 1973.

Gringarten, A. C., et al., "Theory of Heat Extraction From fractured Hot Dry Rock," *Journal of Geophysical Research,* Vol. 80 (1975), No. 8, p. 1120.

Hankin, J. W., R. A. Hogue, R. A. V. Cassel, and T. R. Fick, "Effect of Reservoir Temperature Decline on Geothermal Power Plant Design and Economics," in *Proceedings of 12th Intersociety Energy Conversion Engineering Conference,* Washington, D.C., August, 1978, Vol. 1, p. 870.

Harlow, F. H. and W. E. Pracht, "A Theoretical Study of Geothermal Energy Extraction," *Journal of Geophysical Research,* Vol. 77 (1972), No. 35, p. 7038.

Holt, B. and E. L. Ghormley, "Energy Conversion and Economics for Geothermal Power Generation at Heber, California, Valles Caldera, New Mexico, and Raft Riber, Idaho–Case Studies," Electric Power Research Institute Report EPRI ER-301, Palo Alto, Calif., Nov. 1976.

Khalifa, H. E., "Effect of Seasonal Variations of Ambient Temperatures on the Performance of Low Temperature Power Cycles," Brown University Report COO/4051-10, CATMEC/19, Providence, R.I., June, 1978.

Kruger, P. and C. Otte, *Geothermal Energy,* Stanford, Calif., Stanford University Press.

McFarland, R. D. and H. D. Murphy, "Extracting Energy from Hydraulically-Fractured Geothermal Reservoirs," in *Proceedings of 11th Intersociety Energy Conversion Engineering Conference,* State Line, Nev., 1976.

McGetchin, T. R., *ed.,* "Hot Dry Rock Geothermal Energy: Status of Exploration and Assessment," Report No. 1 of the Hot Dry Rock Assessment Panel, ERDA-77-92, Washington, D.C. (in press).

Milora, S. L. and J. W. Tester, *Geothermal Energy as a Source of Electric Power,* M.I.T. Press, Cambridge, Mass., 1976.

Murphy, H. D., "Thermal Stress Cracking and the Enhancement of Heat Extraction from Fractured Geothermal Reservoirs," Los Alamos Scientific Laboratory Report LA-UR-78-917, April, 1978.

Nemat-Nasser, S., "Minimum Spacing of Thermally Induced Cracks in Brittle Solids," The Technological Institute, Northwestern University, Evanston, Ill. (to be published).

Nemat-Nasser, S., "Thermal Cracks and Their Effects on the Heat Extraction Process," The Technological Institute, Northwestern University, Evanston, Ill. (to be published).

Nemat-Nasser, S., L. M. Keer, and K. S. Parihar, "Unstable Growth of Thermally Induced Interacting Cracks in Brittle Solids," Earthquake Research and Engineering Laboratory Technical Report No. 77-9-2, Northwestern University, Evanston, Ill., Sept., 1977.

Raleigh, C. B., et al., "Multiple Hydraulic Fracturing for the Recovery of Geothermal Energy (abstract)," *E.O.S. Transactions,* American Geophysical Union, Vol. 55, No. 4, p. 4026, 1974.

Ramachandrian, G., et al., "Economic Analysis of Geothermal Energy Development in California," Vol. 1, Stanford Research Institute Report ECU 5013, Menlo Park, Calif., May, 1977.

Rex, R. W., "The U.S. Geothermal Industry in 1978," presented at the Hot Dry Rock Geothermal Information Conference, Santa Fe, N.M., April 19–20, 1978.

Schapiro, A. R. and G. P. Hajela, "Geothermal Power Cycle Analysis," in *Proceedings of 12th Intersociety Energy Conversion Engineering Conference,* Washington, D.C., August, 1978, Vol. 1, p. 857.

Smith, M. C., et al., "Man-Made Geothermal Reservoirs," in *Second United Nations Geothermal Energy Symposium,* San Francisco, Calif., pp. 1981–1787, 1975.

Smith, R. L. and H. R. Shaw, "Igneous-Related Geothermal Systems," in *Assessment of Geothermal Resources of the United States – 1975, U.S. Geological Survey Circular 726,* Reston, Va., 1975.

Starling, K. E., L. W. Fish, K. Z. Iqbal and H. H. West, "The Use of Mixture Working Fluids in Geothermal Power Plants," in *Proceedings of 12th Intersociety Energy Conversion Engineering Conference,* Washington, D.C., August, 1978, Vol. 1, p. 850.

Tester, J. W., *ed.,* "Phase I — Energy Extraction Field Test Results from the Fenton Hill Hot Dry Rock Geothermal System — Segments 1–2," Los Alamos Scientific Laboratory Report (to be published).

Tester, J. W., et al., "Solution Chemistry and Scaling in Hot Dry Rock Geothermal Systems," in *Proceedings of 83rd National Meeting of A.I.Ch.E.,* Houston, Tex., March 21-25, 1977.

Tester, J. W. and M. C. Smith, "Energy Extraction Characteristics of Hot Dry Rock Geothermal Systems," in *Proceedings of 12th Intersociety Energy Conversion and Engineering Conference,* p. 816, August, 1977.

White, D. F. and D. L. Williams, *eds., Assessment of Geothermal Resources of the United States — 1975, U.S. Geological Survey Circular 726,* Reston, Va., 1975.

Wunder, R. and H. D. Murphy, "Thermal Drawdown and Recovery of Singly and Multiply Fractured Hot Dry Rock Reservoirs," Los Alamos Scientific Laboratory Report LA-7219-MS, April, 1978

Ronald G. Cummings is professor of economics at the University of New Mexico, and a visiting staff member to the Los Alamos Scientific Laboratory, where the work reported in this article was done. He was the chairman of the Department of Food and Resource Economics at the University of Rhode Island from 1972–1975 and has held appointments with Resources for the Future, Montana State University and the Kansas Water Board. His degrees (in economics) are from the University of Missouri (B.S., M.A.) and the University of Kansas (Ph.D., 1968). **Glenn E. Morris,** an economist at Los Alamos Scientific Laboratory since 1975, is currently attached to its Energy Systems and Economic Analysis Group. He holds a B.A. degree (1967) from the University of Connecticut and M.A. (1974) and Ph.D. (1977) degrees from the University of Colorado. **Jefferson W. Tester** is leader of the Geothermal Technology Group at Los Alamos; he was assistant professor of Chemical Engineering at M.I.T. and Director of the M.I.T. School of Chemical Engineering Practice for several years after receiving his Ph.D. at the Institute in 1971. In addition to his current work in hot dry rock geothermal energy, he has research interests in applied thermodynamics, process design, heat and mass transfer, surface chemistry and physics, and electrochemistry. **Robert L. Bivins,** a staff member at Los Alamos since 1953, worked in the Theoretical and Computing Divisions before joining the Energy Systems and Economic Analysis Group. He received the B.S. degree from the University of Washington in Seattle in 1952.

The authors acknowledge assistance from R. M. Potter, A. W. Laughlin, and A. C. Eddy in preparing the HDR resource description. R. Hageman and J. McFarland contributed to the computational aspects of the model development, and A. Blair and M. C. Smith reviewed the manuscript. The support of the Division of Geothermal Energy of the U.S. Department of Energy is gratefully acknowledged.

A NEW* CHALLENGE!

PIT YOUR CHESS SKILLS AGAINST THE COMPUTER!

CHOOSE YOUR LEVEL OF PLAY!

*NEW!

10 LEVELS OF PLAYING DIFFICULTY!

From Beginner to Advanced to Expert!

You choose your opponent's level of playing difficulty – from novice to expert. You choose black or white pieces. You enter your initial move. In seconds, the computer analyzes all possible countermoves and makes its best move. Day or night, Chess Challenger "10" is ready to give you a classic battle. The computer will sharpen your game and is the perfect teacher with features like:

- A library of classic book openings
- Random responses – no two games alike
- Does not permit you to make illegal moves
- Solves mate-in-two problems
- Position verification by computer memory call
- Analyzes as many as 3,024,000 board positions
- Double move entry for castling and handicapping
- Hand carved, magnetized French Chess Pieces

Chess Challenger "10" provides the flexibility and variety for a lifetime of classic chess battles. Accept the challenge and order yours today!

U.S. Chess Federation Master has rated the Chess Challenger "10" the best computer chess game and it is "highly recommended".

SPECIFICATIONS:

CHESS CHALLENGER® "10" is housed in a solid walnut case, 13 x 8 x 1-1/4" with felt foot pads. Simulated leather and gold foil playing area and keyboard. U.L. approved 110 volt A.C. 100% solid state for years of trouble-free use. No batteries used.

ACCEPT THE CHALLENGE! ORDER YOURS TODAY!

___Yes, please send___Chess Challenger(s)"10"–$275.00 each plus $8.00 each for shipping and insurance. I understand this is the game rated "best" by the United States Chess Federation.

_____My check is enclosed (N.Y. residents add 5% sales tax).

_____Charge my credit card no._____

_____Visa___Master Charge___Amer. Express Exp. Date _____

Signature_____

Name_____

Street _____

City_____State_____Zip_____

Send to: THE PLEASANTVILLE PLAN, Dept. MIT-7
62 Eastview Ave., Pleasantville, N.Y.10570

Order Toll Free 800-243-5676 – 24 Hours per Day – 7 Days per Week
(Connecticut Residents Call 1-800-882-5577)

Trend of Affairs

Coal-Burning Diesels

Users of large industrial and marine diesel engines, chafing from escalating diesel fuel oil prices, might find relief by rereading Rudolf Diesel's original 1892 patent and ruminating on its implications. He intended his engine, which ignites its fuel by contact with hot compressed air, to burn solid fuels as well as the more familiar — and now more costly — liquid petroleum fuels.

Before diesel oil became the firmly entrenched fuel for compression-ignition engines, innovative designs were successfully run on various powdered solids. In 1916 at Goerlitz, Germany, Rudolf Pavolikowski, an associate of Dr. Diesel, successfully converted a 10-year-old oil-burning diesel to operate on coal dust, sawdust, flour, rice dust and peat. Despite the success of his invention, the Depression and intervening years of cheap and plentiful oil long ago led to its demise. But the emphasis being placed on coal today may exhume, if not revive, his coal-burning brainchild from its half-century of rest.

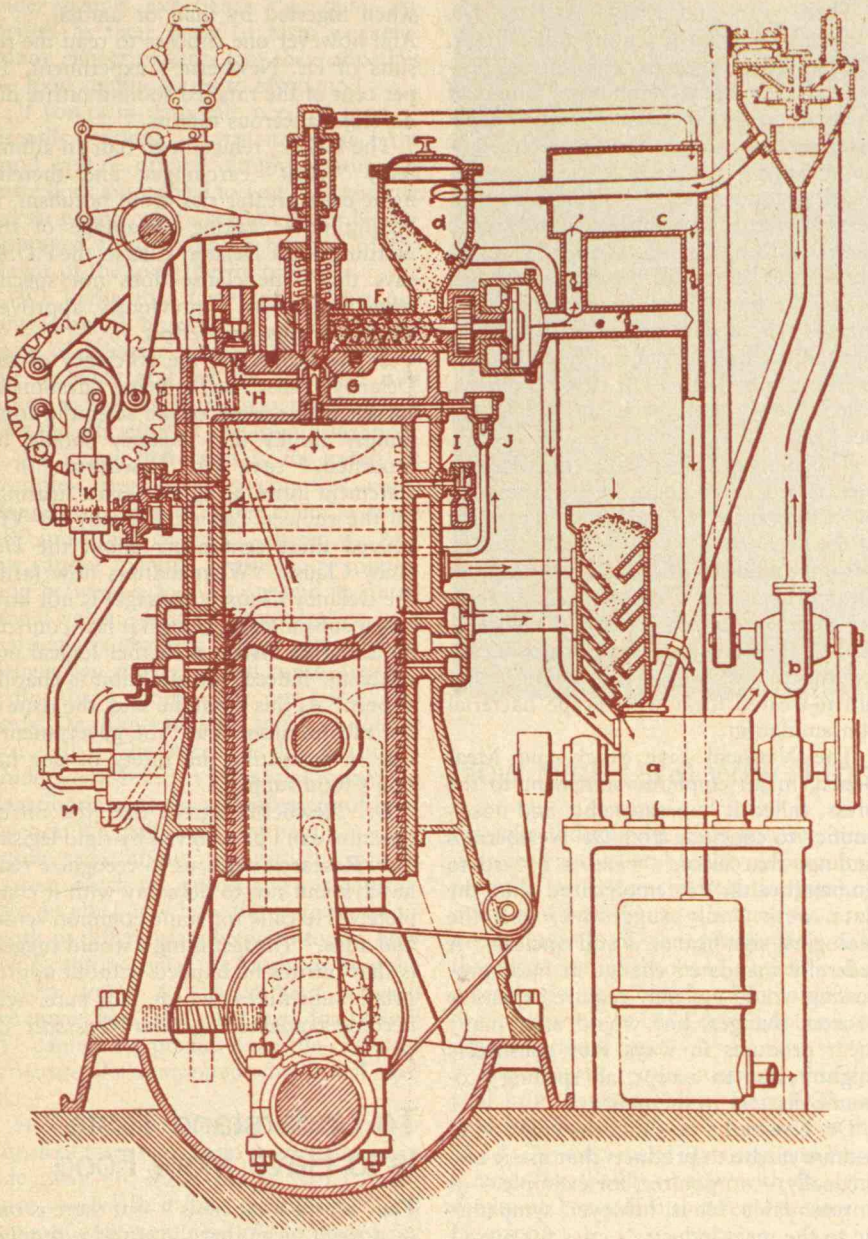
Thermo Electron Corporation in Waltham, Mass., is currently exploring the potential of modern diesel engine designs to burn coal-derived fuels, which include both liquids and solids. The firm's ultimate goal is to determine if such engines could be competitive with their conventional petroleum-fueled counterparts. John Dunlay of Thermo Electron briefed a recent M.I.T. seminar on ongoing research. Two liquid fuels derived from coal and developed under the Department of Energy's coal liquefaction program, have already been tested successfully in huge engines made by Sulzer Bros., Ltd. of Switzerland, yielding power conversion efficiencies of about 41 per cent — indistinguishable from the efficiencies of conventionally-fueled diesels. A coal-oil slurry containing finely powdered coal particles is next in line for testing, and in the future lies the possibility of developing an improved version of a Pavolikowski engine to burn powdered fuel.

The resurrection of the powder-burning diesel will draw heavily from the old designs and also from some general principles. Coal particles burn more slowly than liquid fuels, but disperse "more readily" within the compressed atmosphere of a diesel cylinder, according to Pavolikowski's notes, favoring the use of such a powdered fuel in low-speed engines. A simple rule of thumb: the slower an engine operates, the longer is the time available for combustion, and the larger the particles of fuel that can be burned efficiently. Mr. Dunlay estimates that engines designed to operate at about 100 revolutions per minute (R.P.M.) can burn coal particles from 50 to 70 micrometers in diameter; 1,000-r.p.m. designs require particles no larger than 25 to 30 micrometers, he said. Finer grades of pulverization become increasingly costly, so that the prudent operator will opt for the coarsest powder his engine will burn acceptably.

The economics of producing electricity from diesels fueled by coal derivatives are promising, according to studies referred to by Mr. Dunlay. Overall system efficiency could be boosted from the engine's basic 41 per cent to 45 per cent by employing a "bottoming cycle" to salvage heat otherwise wasted by the engine. In addition, low-speed diesel engines are attractive for industrial cogeneration applications in which they would produce both electricity and process heat. Extensive use of heat otherwise rejected to coolants and the atmosphere could improve the overall energy efficiency of a diesel-based manufacturing plant to 77 per cent, he reported.

At such high levels of efficiency a return on investment of about 20 per cent could be achieved today by large diesel engines that burn residual fuel oil. For example, a system of 14 MW capacity, installed, would cost about $10.7 million, said Mr. Dunlay, and the first year pre-tax savings over current alternatives could be as high as $1.92 million.

Should even residual oil become prohibitively expensive, such engines could be converted to burn coal-derived fuels, including coal dust. Such conversions still await an economic climate that would make them cost effective. Perhaps that time has come. — *L.A.P.* □



This cross-section of Rudolf Pavolikowski's coal-dust-burning diesel engine appeared more than fifty years ago in *Power*. It was actually a conversion from a ten-year old veteran oil-burning engine in a German chemical plant. With a 16.5-inch bore and a 25-inch stroke, the converted single-cylinder unit ran from 1916 to 1924—with its original piston rings—burning various solid fuels, and after rebuilding churned out a steady 80 horsepower at 160 r.p.m. for an additional four years.

The engine consumed about 0.91 pounds of lignite per brake horsepower-hour, leading Pavolikowski to claim that his design was from 30 to 35 per cent more efficient than the most efficient steam turbines of the time and delivered power "at a lower cost than any other fuel-burning prime mover."

Coal fed into an engine-heated hopper was ground in crusher *a*, delivered by blower *b* to a separator above (from which coarse fragments were routed back to *a*) and into chamber *d*. Below *d* two auger-like conveyors *f* delivered the dry, prewarmed coal dust to the intake valve of the engine, one auger screwing the fuel toward the valve, and the other removing excess back to *d*, precluding the clogging of the intake port. Fuel pump *k* injected minute amounts of oil into the cylinder along with each puff of powdered coal to aid combustion and to lubricate the cylinder walls.

Protective Headgear: The Answer Isn't Blowin' in the Wind

We hear periodically from those within the ranks of motorcyclists who vocally express their discomfort with helmets and their disapproval of helmet laws. They generally support their position with arguments on constitutionality and with homelier contentions that helmets impair hearing and therefore safety.

While constitutionality is open to the interpretation of the courts, the laws of nature are far less flexible. To wit: skin and skull are softer than asphalt and concrete. No amount of argument will change that fact.

And now recent experiments at the University of Utah unveil a less known law of nature: that a full-coverage helmet with face shield attenuates wind noise more strongly than it does the sound of sirens and other motor vehicles. Indeed, according to a recent report to the Acoustical Society of America by W. K. Van Moorhem, K. P. Shepherd, T. D. Maleby, and G. E. Torian of the University of Utah, helmets actually helped the subjects hear sounds that otherwise would have been drowned in wind noise.

The methodology of the tests was simple and direct: microphones were mounted in helmets and used to record on tape the various sounds as a rider hears them. The intensity of the recorded sounds was then analyzed and calibrated in decibels, units of acoustic power.

In one series of tests, subjects wearing "wired" helmets rode motorcycles and later stood in a convertible automobile, both moving over the same range of speeds. At 15 to 20 miles per hour wind noise was the loudest sound recorded, far outweighing the sounds of the motorcycle itself, but the overall sound level was 10 to 20 decibels lower than without a helmet. A helmeted rider perceives this drop as a decrease in loudness of 50 to 75 per cent.

In a second series of tests, helmeted and bareheaded subjects were exposed to the recorded sounds of a siren and of an automobile moving at 20 to 40 miles per hour. The subjects reported that helmets do attenuate the intensity of these sounds, but careful measurement showed that wind noise at these speeds would be attenuated equally or to a greater degree. Thus, at moderate speeds, the audibility of these useful sounds was actually enhanced. — *L.A.P.* □

Food and Nutrition

Sodium Nitrite in the Stew

The rats lived at M.I.T., in toxicologist Paul Newberne's fifth floor laboratory. Their quarters were well lit and spotless. Music from a Boston radio station was piped in for their diversion. Their food was monotonous but filling: day after day the laboratory chefs served the rats platters of protein-fortified agar or powdered nutrient or Purina Rat Chow — all seasoned liberally with sodium nitrite. Almost 13 per cent of the rats developed tumors of the lymphatic system.

Laboratory rats aren't the only consumers of sodium nitrite. Sodium nitrite has been on the human menu for over 2000 years. It is the curing agent used in bacon, ham, lox, luncheon meat, hot dogs, and numerous other foods. The familiar pinkness and salty tang of bacon and ham are due to sodium nitrite, and no other curative has been found that makes ham taste like the American public knows it should.

Sodium nitrite is more than a cosmetic, however. Its essential function is to prevent the growth of deadly *Clostridium botulinum* spores in foods. *Clostridium botulinum* grows profusely in nature, and is commonly found in the intestines of fish and mammals. Normal bacteria are destroyed by heat, but these spores resist all but the highest temperatures. Under warm, anaerobic conditions they spread their toxins through food without a trace of color or odor. Less than half of the botulism bacteria's unsuspecting victims survive.

Scientists have long suspected that sodium nitrite might have other, less beneficial, effects. Nitrites combine readily with amines, which are abundant in foods and are present in the human mouth and stomach. Nitrosamines, the result of their chemical marriage, are some of the most potent cancer-causing agents known. Because nitrosamines occur in nature, animals have some physiological defenses against them, so the danger nitrosamines pose is real but unspecified.

Under pressure from public interest groups, the U.S. Food and Drug Administration (F.D.A.) funded a study to quantify that danger. Its first move was to unlink the nitrite-amine chain. In 1975, M.I.T. toxicologist Paul Newberne took on the job of studying the health effect of nitrites. His study was the first to examine the dietary effects of nitrites without the addition of dietary amines.

Three years and 1,954 rats later, Dr. Newberne handed his results to the F.D.A. His stringent tests prove that nitrites promote the growth of lymphomas, tumors of the immune system, in rats — the first real evidence that nitrites by themselves promote cancer.

These results have left quite a few interested parties in positions which are, to them, untenable. Consumer interest groups are calling for the immediate ban of sodium nitrite. Legislators are rethinking the role of government in the protection of its citizens. And the meat industry is casting worried eyes at cured products, which have a retail value of $12 billion per year.

The industry is justifiably concerned. A ban on nitrite would affect the processing of 70 per cent of the pork and 10 per cent of the beef produced in the United States. Also, the addition of sodium nitrite allows meat processors, wholesalers, and retailers some production leeway: if refrigeration in a warehouse breaks down, for example, there's a good chance that nitrite-treated meat will escape bacterial contamination.

The National Live Stock and Meat Board, in an emphatic statement to the press, called it "unreasonable and unscientific" to conclude from Dr. Newberne's findings that nitrite "poses a hazard to human health." It emphasized that the data were "only suggestive, and the biological significance is still unclear." A federally mandated change in meat processing would not only require expensive process changes, but would alter many meat products in ways that consumers might refuse to accept, all spelling economic disaster to the industry.

Dr. Newberne says that the addition of sodium nitrite to products that use it cosmetically — in poultry, for example — is unreasonable. He is, however, sympathetic to the meat industry's cries for mercy, and points out that since no substitute for sodium nitrite exists, and because the threat of botulism contamination is a real one, any federal decision has to weigh the risks with the benefits.

The F.D.A. is taking the most conservative approach allowed to it. But it must uphold the law, and in this case, the law does not recognize relativity.

The Delaney Clause, the law that will mold any F.D.A. decision, is inflexible. It was passed in 1958 as an amendment to the Food, Drug, and Cosmetic Act of 1938, and firmly prohibits the use of any food additive not found to be "safe." "No additive shall be deemed to be safe," the clause says, "if it is found to induce cancer when ingested by man or animal. . . ." And however one chooses to read the results of Dr. Newberne's experiment, 13 per cent of the rats fed sodium nitrite did develop cancerous tumors.

The F.D.A., reluctant to ban an admittedly "weak" carcinogen and thereby incur even greater risk from botulism, is buying time. Taking advantage of the wording of the Delaney Clause, the F.D.A. says that "the clause does not specify when a ban on a previously approved substance must take effect. . . ."

In the meantime, the efficiency of the Delaney Clause itself is being questioned. "A sizable segment of the scientific community thinks that Delaney should be modified," says Dr. Newberne. In a statement introducing the Senate hearings on the subject, Patrick J. Leahy (D–Vt.) offered these sentiments about the Delaney Clause: "What matters now [after the Delaney Clause's passage] is not how safe a substance is, but what law controls its use. This system is neither logical nor coherent. Indeed, the situation is chaotic at best." At this point, he said, the issue is not nitrites alone, but "the government's role in protecting the safety of our nation's food supply."

Dr. Newberne agrees that the nitrite question can't be resolved by rigid legislation. Research helps us to recognize risk, he says, but not to do away with it completely. He calls for some common sense, and adds, "The last thing I would suggest is that nitrites be banned without appropriate substitutes, which, I'm sure, will become available." — *Sara Neustadtl* □

To Understand Taste Is to Have More Food

The "world food crisis" — if there is one — doesn't mean that the world is running out of food. It means that people are running out of food they like — or are willing — to eat.

In this sense, says Professor Morley R. Kare, director of the Monell Chemical Senses Center at the University of Pennsylvania, a better understanding of the mechanism and psychology of taste would be a significant breakthrough in increasing world food supply.

An adult human has a few hundred taste receptors ("buds"); a baby, many more. The system is fully developed at birth and perhaps before: newborn babies have strong preferences for the robust tastes of sweets and salt. As we mature our reactions to taste change, and some

Does this child have lead poisoning? Outward signs of trouble are often absent. As little as 30 micrograms of lead per deciliter of blood may retard brain cell development in children under six; over 40 mg/dl causes significant damage. Blood testing and counseling is available through the U.S. Dairy Association's Women, Infants, and Children (W.I.C.) program and by many state public health departments. (Photo: Lead Paint Prevention Program, Mass. Dept. of Public Health)

older people experience dwindling appetites as their sense of taste weakens. Many cancer patients lose their appetites — food simply ceases to taste good.

If you're in desperate need of food — literally starving — you may reject the food you're offered simply because its taste does not appeal to you. But not vice versa: people who overeat cannot be discouraged from doing so because of the flavor of the food they're offered.

We know that taste has at least one physiological function: it affects the release of digestive reactors, thus preparing the stomach and gut for the food it is about to receive. In this way taste may affect the efficiency of our food utilization.

We know that taste is the result of complex responses to complex compounds — a cup of coffee contains some 300 individual chemical substances. And we cannot identify any obvious connection between a food's taste and its nutritional value — either in general or to a particular individual whose diet may be deficient in some essential constituent.

But that's about where our knowledge ends, Dr. Kane told an M.I.T. audience last fall as he received the Institute's Underwood-Prescott Memorial Award for contributions to the advancement of food science. We really know very little in a scientific sense about taste and the human system which recognizes and evaluates it. We do not know how the taste receptors work to differentiate between foods, how the receptors signal the brain, or how the system works to discriminate between what we "like" and what we "don't like." We cannot yet predict from the chemical structure of a compound what it will taste like.

Such an understanding of the mechanism of taste may be no more than a decade away, Dr. Kane told his M.I.T. audience. And with it food technologists will have an important new tool for increasing the efficiency with which world food materials are used. To explain this connection between taste and the "world food crisis," Dr. Kane cited examples of food materials in plentiful supply throughout the world which are not used because they don't "taste right" to the hungry people who need them. With better knowledge of taste and the psychological reactions it invokes, he said, some of these now-underutilized resources might be made useful — even popular. — *J.M.* □

How High (and Why?) the Cost of Malnutrition?

It's now indisputable that poverty, malnutrition, and mental health are interconnected in American children. But psychologists and nutritionists are far from a full understanding of the relationship, and there is as yet no theory to explain it. Research on what is clearly a "complex web of interactions" in child development is an urgent national need.

Three recent results stimulate this appeal from Ernesto Pollitt, Darryl Greenfield, and Rudolph Leibel, formerly of the M.I.T. Department of Nutrition and Food Science (Dr. Pollitt is now with the University of Texas Health Science Center in Houston).

□ Drs. Pollitt and Leibel examined the social situation of 19 Cambridge, Mass., children between the ages of two and six who were undersized and underweight, but for whom there was no evidence of organic derangement as a cause for their diminutive size. In 16 cases, three social variables appeared prominently in family histories of these children: poor mother-infant interaction, little assistance to mothers in caring for children, and family poverty.

□ A recent study in New York City shows that the overall rate of low-birthweight infants there in the early 1970s was 93 per 1,000 live births. Conditions of overcrowded living and/or low family income were associated with 64 per cent of these, and separation and divorce was an issue in an additional 16 per cent of these cases.

□ Preliminary results by the authors suggest that iron-deficient children in Cambridge are less responsive to information, less effective at remembering information, and less responsive to external stimuli than non-iron-deficient children.

"These are complex issues; cause-and-effect is hard to establish, and research is slow. Anyone who has the temerity to seek to unravel some facet of the Gordian Knot which binds nutrition to behavior needs little instruction in the frustrations involved," write Drs. Pollitt, Greenfield, and Leibel.

Furthermore, it's a two-directional problem. "We know more about the influence of nutrition on behavior than the converse," write the M.I.T. scientists. Even with more information on the effects of malnutrition, remedial programs will have little potential until we understand how nutrition-related decisions are motivated in typical American consumers of all backgrounds and classes. "Only through the development of a . . . complex socio-medical calculus will we ultimately be able to . . . make the difficult decisions regarding the most effective disposition of health-care dollars." — *J.M.* □

The Megamyth of Megavitamins

Our culture is enchanted with the grandeur of size. It also has a peculiar passion for popping pills. Megavitamin dosing satisfies both of these affections. Ever-increasing numbers of people are consuming ever-greater amounts of vitamins: E to enhance sexual potency; C to ward off the common cold, and so on.

Yet separating scientific fact from the fog of rumors and anecdotes leaves little scientific proof that megavitamin dosage is useful. The public is wallowing in a "sad state of confusion" about megavitamins according to Dr. George Wolf, professor of physiological chemistry in the Department of Nutrition and Food Science at M.I.T.

Orthomolecular psychiatry, which has emerged from the theory that megadoses of vitamins can cure mental disease, said Dr. Wolf, is probably the basis for today's megavitamin faddism and "really needs clearing up by some clinical experimentalists" who rely on rigorous standard testing procedures to validate or disprove its theories. In the early 1960s, two Canadians named Osmond and Hoffer unearthed a 1939 U.S. study with schizophrenics, in which psychiatrists successfully treated a group of elderly people suffering from mild neuroses with small supplements of niacin (vitamin B-3). Osmond and Hoffer decided to try larger doses of niacin on schizophrenic patients, also claiming success. Linus Pauling theorized that schizophrenics suffer from an enzyme-niacin imbalance in the brain, and termed this a "local cerebral deficiency disease," and founded orthomolecular psychiatry, the aim of which is to correct the proportion of niacin to enzymes in the brain.

Dr. Wolf called the Pauling hypothesis a "very interesting one," but cautioned that the theory was never tested adequately due to a split between the orthomolecular advocates and the conventional scientific community. Scientists were initially antagonized when the supporters of the theory turned to the popular media to gain acceptance of their controversial ideas, Dr. Wolf explained. Later, the orthomolecular advocates began to publish their own journal, including in it all the anecdotal incidents in which they claimed their treatment had been successful. This last action sufficiently dissuaded scientists from pursuing tests on the theory, he stated.

Dr. Wolf personally doubts that there is any substance to the orthomolecular theory, and cites as a basis for his belief a 1973 Public Health Service study done by Dr. J. Richard Wittenborn from Rutgers University. The Wittenborn study was performed on 140 schizophrenic patients over a two-year period. Half received normal niacin doses and half, megavitamin doses. In addition the diet of both groups was carefully controlled. Dr. Wittenborn found that no significant psychiatric differences developed between the two groups. Wolf conjectures that the patients in the 1939 study, who received "relatively small amounts" of niacin, were most likely suffering from the early stages of pellagra, or niacin deficiency, which can produce mental disorder. This explanation is a far cry from extrapolating that enormous doses of niacin will cure schizophrenia.

Orthomolecular psychiatry spurred Dr. Pauling's interest in megavitamin dosing. Searching through the medical literature, he came upon a story of how skiers in Switzerland who had taken large amounts of ascorbic acid seemed to exhibit fewer cold symptoms than those who did not. Dr. Pauling tried this on family and friends, and concluded that the idea did have some merit. He published *Vitamin C and the Common Cold* and the ascorbic acid stampede was on.

The effect of ascorbic acid (vitamin C) on the common cold is one instance where Dr. Wolf tempered his skepticism about megavitamin intake. Although ascorbic acid in large amounts does not cure the common cold, he said, it does behave like a mild antihistamine to ease cold symptoms' severity. While vitamin C can mitigate the symptoms of an existing cold, but Dr. Wolf insists that the ever-elusive cure for the common cold still continues to evade us, and still recommends pharmaceutical antihistamines for this task.

Dr. Pauling derives his vitamin C megadose argument from two specious premises, Dr. Wolf suspects. Since all animals except primates and guinea pigs manufacture their own ascorbic acid, Dr. Pauling looked to the amount that rats produce, calculated a proportional amount for humans based on weight, and arrived at a figure of two grams per day. Dr. Wolf counters that nutritional requirements are based on metabolic rate rather than weight. Therefore, the scaling-up should be done according to metabolic rate, not weight. This procedure would result in a much smaller amount than two grams. Secondly, Dr. Pauling asserts that primitive man and large apes obtained their two gram daily supply from eating large amounts of vegetable matter. Dr. Wolf dismisses this as a weak point. The human body simply excretes most of this enormous quantity in its tissues. Indeed, any amount of ascorbic acid above the body's daily need — 45 milligrams — is excreted with the urine. An experiment by Dr. Richard Hodges at the University of California, Davis, showed that of the body's one-and-a-half-gram "pool" of ascorbic acid, only three per cent, or 45 milligrams, is metabolized daily and must be replenished.

Furthermore, there are some indications that huge intakes of ascorbic acid can have adverse effects. Recent experiments have shown that it could raise cholesterol levels in rats. Moreover, a few cases of "rebound scurvy" have been reported. This occurs when the body develops an addiction to large doses of vitamin C. If the body does not receive its customary enormous dose, then normally sufficient amounts may not prevent the onset of deficiency symptoms. Wolf admitted that these occurrences are rare. Therefore, the best way to use ascorbic acid in battling the common cold is to restrict large doses to the times you develop cold symptoms.

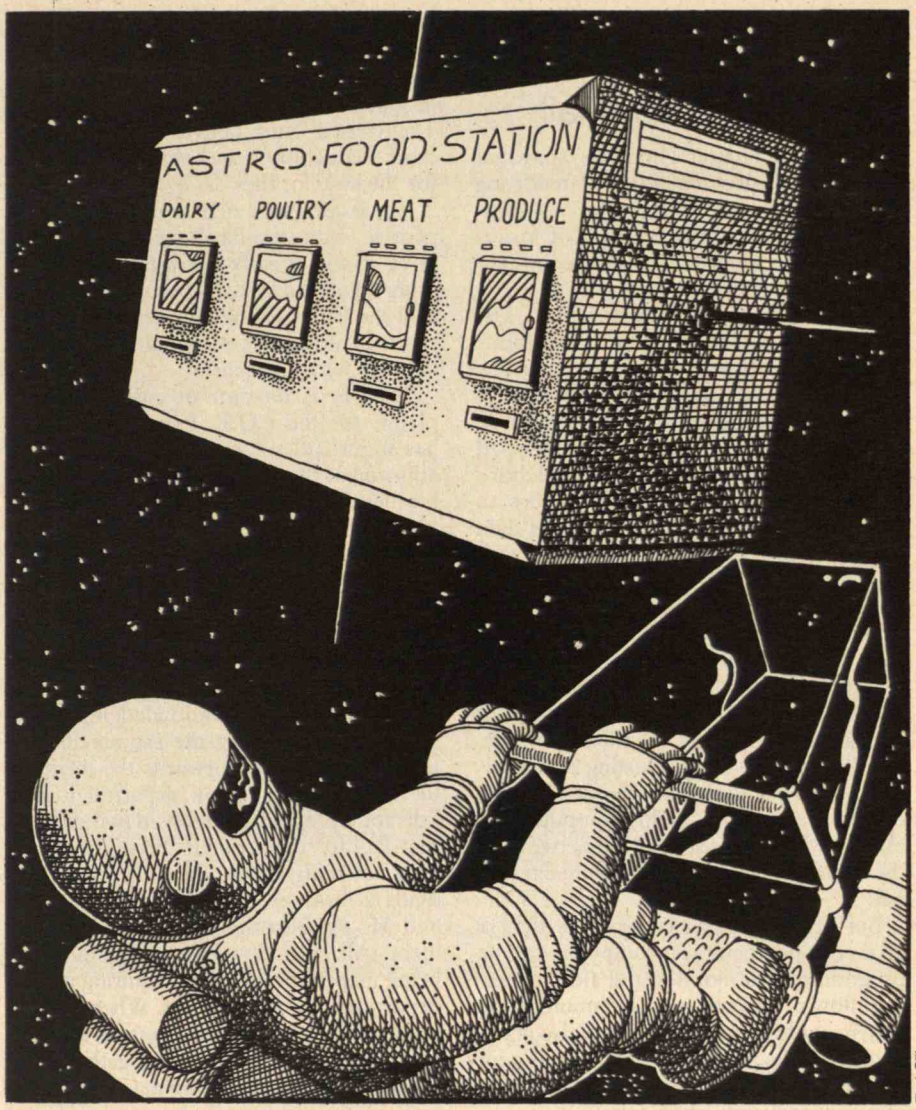
Much to the dismay of the Ponce de Leons and Casanovas of the world, experiments support none of the marvelous claims about the value of huge amounts of vitamin E. In fact, with one exception, we still are not sure that E is necessary for humans at all: lack of vitamin E can produce fragile red blood cell membranes in infants. Large amounts of E can interfere with intestinal absorption of other fat-soluble vitamins, particularly D and K. Excessive amounts of E, which are any amounts above ten milligrams per day, are expelled from the body with fecal matter. There are some species specific deficiencies of vitamin E, but, with the above noted exception, none for humans. Vitamin E, for the most part, still remains enigmatic.

On the other hand, vitamin A in large doses can be extremely dangerous. A person ingesting only five times the recommended daily allowance over a six-month period can incur vitamin A poisoning, which can lead to sickness and even death. An excess of vitamin A raises cerebral fluid pressure, which can lead to acute problems such as headaches, nausea, lethargy, vision disorders, and in infants, hydrocephalus, when the soft bones of the skull expand from increased pressure. Most of these problems are "completely reversible" within a week after the afflicted person returns to a normal intake level. If a woman in the early stages of pregnancy ingests excessively large

amounts of vitamin A, it may lead to birth defects. One man in Britain who consumed a gallon of carrot juice daily as well as massive doses of vitamin A in the form of pills died from vitamin A poisoning. Wolf warned that we will "see more of that as more people get interested in megavitamin dosing."

Vitamin A becomes troublesome when it manages to travel freely in the bloodstream. Usually, it is bound tightly to a carrier protein, which transmits it to another cell where another protein is awaiting its arrival. This is necessary because the vitamin acts like a surfactant, and will dissolve cell membranes if it passes unguarded through the bloodstream. This only occurs when the liver, which stores the vitamin, becomes saturated and the vitamin spills into the blood.

With the exception of vitamin A, megavitamin dosing seems to wreak its major harm on one's pocketbook. If you have been feeling depressed lately, are drinking a bit more than you would like, are bothered by a lack of sexual prowess, or are developing a sniffle, enormous vitamin doses will probably leave you in the same sorry shape you're already in. — *David M. Ross* □



Ted Sillars

Food in Space: Orbiting Black Markets?

The growth of crops and animals within a space colony, although dramatic in concept, will be only one step in the vital nutritional process. The conversion of raw food materials into final, packaged form represents the major — if unsung — part of the trek from pasture to palate.

Marcus Karel, Professor of Food Engineering at M.I.T. told the A.A.A.S. in Houston last month that it is imperative for planners of space nutrition programs to study carefully food processing, packaging and dispensing on earth before letting fly their designs into extraterrestrial settings. These operations command most of the U.S. food budget today: about 24 to 32 cents of each food dollar goes to the American farmer, he said, but 39 to 48 cents — the greatest fraction — pays for food processing and food service; 8 to 13 cents goes for packaging; and 5 to 8 cents, for transportation. The remaining 7 to 16 cents is expended in various other ways, such as the disposal of waste materials. In all, about half of the energy flow in the U.S. food chain is expended in preparing and processing food for market.

Numerous schemes are being devised for closing the cycle of food production in space colonies — the goal being to produce nutritional raw materials in space. These raw materials must then be refined to make them into foods. Miniaturization of food processing equipment is a task still to be undertaken, he said. To achieve optimal efficiency, food preparation will necessarily be transformed from a home to a factory operation, said Professor Karel; for example, the dispensing of food may be more efficiently done by machines than by kitchen personnel.

Potentially profound psychological factors resulting from unfamiliar means of food preparation and food service have yet to be addressed, he warns. Once established, nutritional procedures in a space colony are likely to become frozen because "efficiency considerations will be supreme," he said, so that eating space cuisine could become monotonous. Some items could become luxuries, conceivably inspiring a black market, for example, chewing gum, coffee, and that old bugaboo tobacco, he said, (offering the hope that smoking will be prohibited in space colonies).

While such a speculation may be tested only through actual conditions, the likelihood of one possible problem — out-of-order vending machines — does have firm roots in today's experience. To colonists depending on such devices for sustenance, such food delivery foul-ups could, however, be much more than a frustrating inconvenience. — *L.A.P.* □

Computers

Gonzo Computer Mail

Just as writer Hunter Thompson spawned the anarchic, personal form of reporting known as "gonzo journalism," so computer experts could be accused of fostering an explosion of "gonzo computer mail" in the very near future.

According to participants in last December's National Telecommunications Conference in Los Angeles, the next few years should see a remarkable increase in the number of businesspeople taking care of business via computer messages typed out on the company's terminal. Even hobbyists will link up over phone lines to trade gossip, programs and assorted data in a sort of "CB computer mail," they predicted.

Unlike traditional electronic mail such as telegraph and Telex, computer mail frees the operator from the "teletypewriter priesthood," said Raymond and Rosemarie Panko of the University of Hawaii. In their paper for the conference, they described several existing and projected systems in which the sender can compose a message at his computer terminal and transmit it over the network to the appropriate person at another terminal.

But computer mail is far more than a gizmoed teletypewriter; computers can be programmed to monitor and aid the message flow in ways no mere communication system could hope to. They will also act as filing clerks, editors and intelligent partners in message traffic, thereby almost certainly reducing labor costs.

Powerful economic incentives will almost certainly encourage the rise of such commercial services, said the Pankos. While a typical telegram or telex message costs from $1 to $2 to send, a simple computer mail system costs only about a nickel per message on high-volume routes. A more sophisticated system would have a per-message cost of about $.50 today, dropping to about $.15 in 1985, they estimated.

Labor costs are major contributors to the cost of communications. For example, most of the $5-to-$10 price of preparing and handling the average business letter is attributed to labor costs.

Direct economic comparisons alone still don't fully illustrate the advantages of computer mail, said the Pankos. Indirect savings may actually make the computer mail system more than pay for itself. Since Hewlett-Packard switched from Telex and other forms of communication to its own error-detecting computer mail system, the error rate on their business forms has dropped from 10 per cent to 4 per cent. The clerical and delivery savings from error deduction may actually have paid for the system, they said.

While computer mail is definitely competitive with standard message systems now, it will greatly outdistance them as more advanced systems become available, said the Pankos. They illustrated the possibilities of future systems of the next few decades with a scenario:

"Mr. E. is director of customer complaints for the P.Q.R. Company. P.Q.R. has about 200 industrial clients, and rapid adjustment of complaints is crucial for the business. Adjustment can be very complex, and control of the necessary procedures is very important.

"When a complaint arrives, Mr. E.'s secretary types it into the computer, along with Mr. E.'s assignment of a responsible department. Now the computer takes over. It sends a Telex message or telegram to the customer, acknowledging their complaint and giving the estimated date for a reply. It then forwards the message to the suggested action department and asks for a preliminary reply in two days. If the P.Q.R. department first contacted does not reply in two days, the computer sends a message to both the department and Mr. E. Sometimes the action department will turn down the assignment as being inappropriate, thus requiring a new department to be contacted. When a reply does finally come in, the system sends a copy of the reply to Mr. E., together with a copy of the initial complaint and a history of the company's past complaints. Mr. E. then calls the client to discuss the situation. If action within P.Q.R. is required — for example, the shipping of goods by a certain date — the computer monitors shipment and warns Mr. E. of any impending variances."

The Pankos and other conferees also projected a rapid growth of "CB computer mail" — communications between home computers over phone lines — spurred by the rapid public acceptance of the cheap computers now coming onto the market.

"Freewheeling public graffiti conferences" have already proven extremely popular in existing systems, said the Pankos. "We suspect that some form of CB computer mail could prove economically attractive even at low community penetrations."

Such a wild and woolly world of computer mail — in which computer freaks and corporations alike ply the wires with their wares — could add a considerable confusion to the traffic, warned conferees.

Nevertheless, upon reviewing the history of the 180-computer ARPANET (in which M.I.T. is a participant), T. H. Myer and John Vittal of Bolt Baranek and Newman, concluded that ARPANET's "laissez-faire" attitude was the best for governing computer networks.

While the ARPANET computer message service provides basic ground rules for how messages are formatted and transmitted on the system, they said, each user can handle messages as they wish on their particular computers and send whatever information they wish. The network, consisting of 33 different host computers from eight manufacturers, has worked well, said Messrs. Myer and Vittal, leading them to favor a philosophy of loose organization for public computer networks.

"One might argue that this is an outlandish proposition, hardly the appropriate scenario for creating an effective large-scale communications service," they said. "But is it really so outlandish? For those who believe that free enterprise yields the best ultimate service to the consumer, this approach would offer free enterprise with a vengeance.

"For the price of a network connection, any computer operator could tap into the global message flow, offering his own brand of end user service at his own price. Competition would encourage the development of cost effective services and foster a lively exploration of new and imaginative kinds of service."

But according to Elizabeth J. Feinler of SRI International such free enterprise could lead to chaos. The simple person-to-person message will be only a part of the polyglot of computer message flow, she warned. "Programs will be talking to programs, as well as people to people. Forms and orders will be directed to processing points, 'bug' reports will be directed to gripe files, reminders and notices will be sent by 'daemons' (programmed reminders) that wake up at intervals and fire off canned messages, data subsets will be collected and deposited automatically, files will be transferred from one host to another, spoken messages will be digitized and transmitted, optically-scanned printed matter will be translated into computer files, and any number of other procedures that we have probably not yet imagined. "The need for clean, clear, precise protocols and data standards becomes very critical under this kind of usage," she said.

One major need will be a sort of supercomputer telephone book, containing all sorts of information about a person's background, interests, and even organizational membership. Such listings, entered and periodically updated by the individual, would enable fellow networkers to pick him out for specific messages. For example, one person might desire to send messages only to those people who hold a pilot's license. A business organization might want to send product information to members of a particular profession interested in their wares.

Organizing a computer network is not easy, said Ms. Feinler; even the basic problem of persuading people to use some sort of identifying code is difficult. "Persons who do not object at all to having a telephone number, go into a three-way tizzy fit when they are assigned a computer number," she observed. And what if a person's name is used as an identifier, plus an added number to distinguish duplicate names?

"It can be categorically stated that humans adhere strictly to the rule of Numero Uno, and do not take lightly to being told that they are JONES-3 instead of being the first and only JONES on the network," she said. "Also, people often insist on rather bizarre monikers which are offensive, or too long, or have already been assigned to someone else."

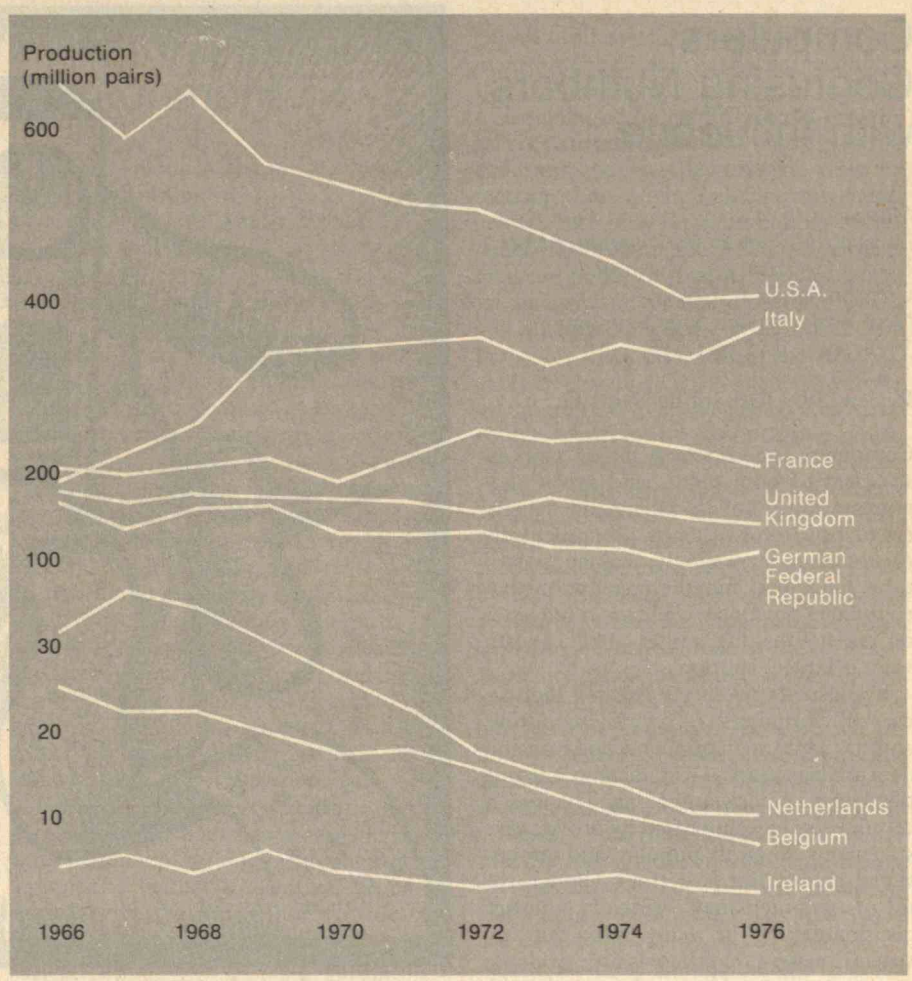
Such problems aside, the attractions of computer mail seem too good to pass up, for both business and for the average computer freaks looking for something to do with their new toys. — *Dennis Meredith* □

Computers for Shoes

Total U.S. production of nonrubber footwear has fallen by 40 per cent in the past decade, and no change in the trend is in sight. Today's U.S. shoe industry, confronted with extremely strong foreign competition, is faced with a challenge to its survival: to find new ways to create ever more diversified product lines in response to consumers' needs — and fads — at lower cost and with ever greater speed.

The problem has been exacerbated by the historical failure of the shoe industry to invest in manufacturing research and development. Now the industry is not only behind the times; it has no backlog of talent and experience to which to turn for help, say Frans Van Dyck and Professor Nam P. Suh of M.I.T.'s Laboratory for Manufacturing and Productivity, completing a study for the Department of Commerce. Short-term changes to improve productivity include improvements in cutting, stitching, and trimming methods and the detection and correction of flaws in materials, based on technology familiar to other industries. But one recommendation overshadows all these: turn to computers for management help.

Bad news from U.S. shoe factories: while shoemakers in many European countries have been claiming a growing share of the world market, U.S. shoe production has fallen steadily since the 1960s. Now the industry is too poor to afford the "computer revolution" it needs to modernize management and manufacturing, and Dr. Frans Van Dyck and Professor Nam P. Suh of M.I.T. propose an industrywide cooperative research and development program.



Computers are now inexpensive; any company can afford one and immediately put it to work in materials and inventory control, ordering, shipping, invoicing, and sales analysis. Taken together, such uses would represent a kind of "computer revolution" that would increase the efficiency of many shoemakers who are now befuddled by the enormous variety of numbers they must deal with when making small quantities of many different styles and sizes of shoes from many different materials and components. Computers will save all along the line; but most important of all is the time they will save a shoemaker when designing and introducing a new style. In this case computers will provide a competitive edge against foreign makers remote from the U.S. market.

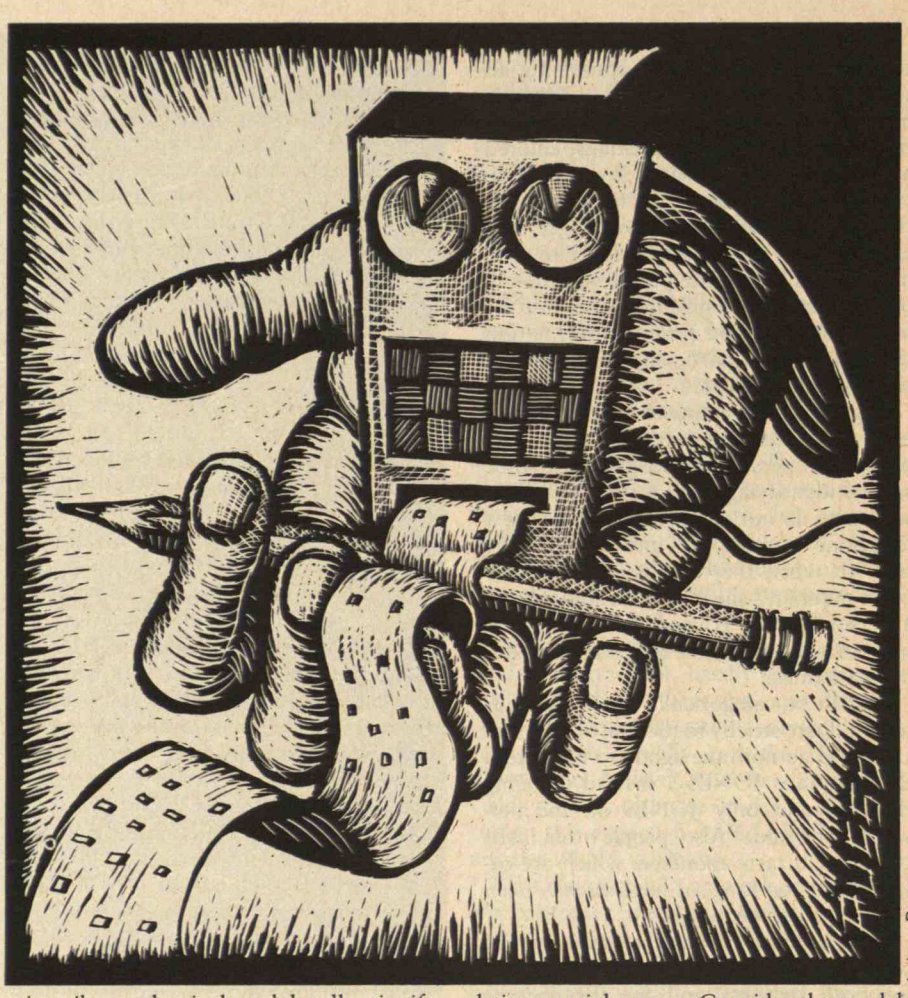
Over the longer term, Drs. Van Dyck and Suh propose to extend their computer revolution to computer aided design (CAD) and computer aided manufacturing (CAM) in the shoe industry. They also call for research on new materials and new techniques for assembling shoes (the operation of stitching machines now accounts for 75 per cent of the labor cost in shoemaking, they write).

No single footwear manufacturer is rich enough to afford this kind of research and development today. Drs. Van Dyck and Suh would have the Department of Commerce solve this problem by underwriting a new cooperative footwear technology program. It would assure "a continuous development of more productive technologies for the U.S. footwear industry," they write, and soon enough it would generate the profits needed by the industry to assure its — and its sponsors' — future. — *J.M.* □

Computers: Confusing Numbers with Influence

Models in the Policy Process: Public Decision-Making in the Computer Era
Martin Greenberger, Matthew A. Crenson, Brian L. Crissey
New York: Russell Sage Foundation, 1976, xx + 355 pp.; $15

Reviewed by Richard de Neufville



Anthony Russo

Computers are clearly a major new instrument of both public and private administration. Public officials and managers of private institutions are, practically everywhere, increasingly making use of these machines. But the assumption that computers obviously wield great influence on decisionmaking, either public or private, is largely spurious.

It is usually taken for granted that the use of computers — whose wondrous abilities to store, manipulate, and transmit data are legendary — is radically changing the nature of decisionmaking. The idea is certainly widely supported by provocative statements in both popular and professional media. But is it true? Though the use of computers may eventually influence decisionmaking in many important respects, I believe that there is little evidence to suggest that computers have so far significantly affected the content and process of decisionmaking — as distinct from its aura and documentation.

The Ball-Point Era?

This fallacy is promoted through the use of evocative language in a misleading way. Consider the title of the book *Models in the Policy Process: Public Decision-Making in the Computer Era.* The phrase "the computer era" implies that this innovation has a dominant effect. Yet we wouldn't name an era after just any pervasive technical innovation used by decisionmakers (the ballpoint era? the Xerox era?). What then is special about computers for decisionmakers? Their speed of calculation? Hardly plausible; government decisions now seem to come slower than before. Neither is it the computer's ability to store information: file cabinets still hold most government records. True, the size and speed of computers are important for many purposes, such as preparing payrolls and switching telephone circuits, but these activities are primarily mechanical and hardly signify decisionmaking. In thinking about the possible effect of computers we must not confuse evidence of the computer at work — or of Xerox machines or ball points — with influence. If there is a "computer era" in decisionmaking, it must depend on some deeper concept.

A major new ingredient in decisionmaking is the use of highly complicated representations of reality, whose detailed implications need to be worked out by computer. These models could be seen as the evidence that computers now have a central role in decisionmaking. Certainly, the authors say as much in their title. I emphatically disagree.

To accept that the use of computerbased models fundamentally alters the policymaking process is, I believe, to confuse form with substance. Models of how the world works — of how aggressive nations react to appeasement or criminals to repression — are the flesh and blood of the arguments over policy. To spell these out in computer code in however much detail — or to write them in French, for that matter — does not change their essential nature. Consider the model behind Meadows' *Limits to Growth,* for example. Once all the computer trappings are brushed away we have a model that says that, in a world of fixed resources, rapidly growing appetites ultimately lead to disaster. Malthus said it all. The computer added nothing of substance.

Old Tales of Conflict

A full discussion of models in the policy process, of how preconceived notions of cause and effect shape our perceptions of problems and sense of possibilities, of how these concepts develop and gain hold of the body politic, could be most useful and provocative. It would not be limited to computer models, as is the story told by Messrs. Greenberger, Crenson and Crissey.

Their story is quite different. In the main it is a series of case studies of the fate of various efforts to develop and gain acceptance for computerbased models for public policy. It is mostly a tale of frustration and of conflict between the technical experts and politicians, public officials

and other decisionmakers for the public. As such it is a useful addition to the literature.

But the authors tell their story as if the tensions they describe were particular to computerbased models. It isn't. Decisionmaking for public policy inherently involves conflict. It may either be explicit, as in pluralist societies such as the United States, or implicit, as in more autocratic nations such as France. In any case, public decisions are typically quite different from decisions in the private sector, where the bottom line of profits usually prevails. Policy arguments reign between groups holding incompatible goals and values, between regions or sectors of the economy, and between the technical people who want to influence policy and the nontechnical people who dominate decisionmaking processes.

The conflict between the technical expert and the layman is typical of debates over public policy. Recently, with the development of computer models, the instruments of this battle have changed somewhat. But the new instruments have not created the situation nor, I believe, have they transformed it profoundly so far.

A more enlightening text would have resulted if the authors had given us the book suggested by its title: this first would identify if, and then explain how computer models have altered the basic processes and general range of outcomes of public decisions. The experience of M.I.T.'s Technology and Policy Program leads me to suggest that the long-term effects of computers on public decisionmaking may be most subtle. A principal effect may be a change in the outlook and expectations of engineers. Computers, by extending their analytic capabilities, help legitimize their concern with broader, longer-term, more complicated issues in planning. They would thus seem to enable engineers to bridge the gap between the most narrowly focused technical issues and the larger public issues.

Professor Richard de Neufville is chairman of the Technology and Policy Program at M.I.T. He works on transportation problems for American and foreign governments. His most recent book is Airport Systems Planning: A Critical Look at the Methods and Experience *(reviewed in June/July, p. 14).*

An Economy for the Environment

The New American Dream Machine
Robert L. Sansom
Garden City, N.Y.: Anchor Books, 1976, vii + 251 pp.; $8.95

Reviewed by Daniel V. Edson

Early this year, I read the reprint of an energy speech given by a chief executive of a major U.S. corporation. In his simplistic review of America's energy future, he took a wild and particularly vicious slap at proponents of what he termed "soft energy" — those who would support a significant decrease in the energy growth rate and would encourage *lifestyle change.* In addition to suggesting that these trends could force Americans to relinquish important social gains, halt medical care improvements and revert to the backbreaking toils of the 1800s, he threatened that extreme energy growth rate reduction might prompt calamities such as social upheaval and even revolution.

Unfortunately, this reaction to the prospect of lifestyle change in America is not uncommon. By and large, the American public neither understands what is meant by lifestyle change nor why lifestyle change is necessary. To Robert Sansom, though, the reasons are obvious: to live in harmony with the environment, Americans must change their living habits with relation to energy use, automobile use, and land use. An economy based on environmental harmony is described in *The New American Dream Machine.*

Author Sansom, the Environmental Protection Agency (E.P.A.) administrator of air and water programs from 1972–74, divides the environmental movement in America into three phases, industrial and automobile pollution control, lifestyle change, and environmental growth. Phase I, which began in 1969 on the oil-drenched beaches of Santa Barbara, concluded in the mid–1970s when environmental controls on industrial air and water pollution and automobile emissions became effective.

Phase II: Lifestyle Change

Present pollution controls, though remedial, are not enough: No foreseeable technology will assuage American's growing demands on the environment.

According to Sansom's timetable, Americans must now enter Phase II, a period of lifestyle changes that will create a manageable, self-regulating economy that permits a steady increase in standard of living based on *environmental growth,* rather than *energy growth.* Success in this endeavor, he has determined, rests on meeting three goals: reducing the energy growth rate to 2 per cent, ending dependence on the automobile, and developing land use policy in tune with environmental, energy, and æsthetic considerations.

Reducing our energy growth rate to 2 per cent — less than half of the 1965–73 average growth rate — will have varying effects on lifestyle. Increased industrial energy conservation, co-operative power generation (greater utilization of by-product heat energy, too often labeled "waste" heat), and more energy-efficient freight handling systems, will require few sacrifices from the public. However, a reduction in energy spent on heating and cooling homes and commercial buildings, the control of superfluous "convenience" appliances, and extensive recycling will certainly demand more diligence. The intent must be to squeeze more output per unit of energy, while identifying and eliminating energy uses that have but a marginal impact on the standard of living.

Sansom prescribes domestic coal for the primary fuel supply, but only with the use of scrubbers. Other sources should include domestic oil and gas, conservative use of nuclear energy, and various alternative sources. Unfortunately and inexplicably, he fails to give solar energy the boost it both needs and merits.

His proposition to end dependence on the automobile cannot be considered lightly. The cries that rose when an upstart E.P.A. attempted to sharply limit traffic in smog-shrouded cities in the early 1970s served notice that many Americans would sooner choke than accept other means of moving from point A to point B. Breaking this most profligate American penchant will require a combination of financial penalties — increased fuel costs, taxes on heavy and inefficient automobiles, and rigidly enforced lowered speed limits — and increased availability, reliability, and convenience of mass transit. Also, disincentives to drive, such as reduced parking in crowded population centers and outright bans in some urban areas will discourage automobile use where pollution levels are most noxious, without penalizing rural Americans who must depend on the automobile, having no practical alternative.

Land use is inextricably affected by both energy growth and automobile dependence. The greater our energy de-

mands, the more land needed for mining, transportation, and power plant construction. A continuing increase in auto use, too, impinges on land use by requiring more highways and parking and through the seldom recognized but extremely serious water table pollution from crankcase oil emptied onto the ground.

Controlling land use might employ such measures as establishing population density limitations, based on the capability of a location to accommodate man; regulating the use of mountain and seashore land for private second homes; discouraging the sale of farmland for non-agricultural uses by stiff financial penalties; and promoting such concepts as *environmental trusts* or *land banks,* in which landowners relinquish the right to sell or develop land in trade for reduced taxes.

Persuasion by Government

Sansom estimates that the energy growth rate can be reduced to about 3 per cent solely by permitting energy prices to rise until they more closely reflect availability. To shave the next percentage point will require government intervention such as gasoline taxes, automobile weight taxes and regulation, traffic control, tax incentives for installing energy-saving equipment (industrial, commercial and residential), reusing/recycling regulations and stronger environmental impact studies.

To be successful, lifestyle changes must be economically stimulating. Government guidelines, regulations and policies will have to play a major role in establishing the economic incentives to force lifestyle change. Though the E.P.A. has more White House support now than under the previous two administrations, Sansom doubts that much lifestyle change can take place without giving the agency greater authority. To strengthen the environmental regulatory needs of the country, Sansom proposes to dismantle the Department of the Interior, and form a Department of the Environment from the E.P.A. and the land use and parks and recreation side of Interior. A Department of Energy and Natural Resources could result from merging the old Federal Energy Administration with the natural resources side of Interior. Both would enjoy cabinet-level status.

Gazing into the twenty-first century, Sansom allows a bit of unpretentious idealism and describes his Phase III, environmental growth. In this period, the protective systems he carefully designed and outlined in *The New American Dream Machine* will be effectively controlling energy growth rates and fostering an economy based on the environment. Lower economic demands are expected to result from stabilized population levels, and the pace of improvement in clean-up technology will comfortably exceed that of economic growth. All very nice, but a bit too distant to plan a vacation around.

Fortunately, Sansom does have friends in high places. Since his book was published, and since I read the alarmist corporate energy speech, the president has indicated a desire to reduce the energy growth rate and the energy program recently announced by the government includes tax credits for industries and individuals who invest in conservation equipment and renewable energy sources, and tax penalties for those who purchase low-mileage automobiles.

Further, *Fortune* magazine reported in a recent industrial energy outlook that by "redesigning and rearranging" the industrial processes to conserve fuel, Americans might greet the year 2000 with a higher standard of living than now enjoyed, at no increase in energy use. And energy chief James R. Schlesinger has added his support, stating that he sees no "hard and fast" connection between energy use and GNP. The proposition of lifestyle change in America, though not well accepted yet, finally may have come of age.

Daniel Edson is a science writer in the Boston area. □

Sovetskaia Tekhnologiia

Soviet Science, Technology, Design
Raymond Hutchings
London: Oxford University Press, 1976, 320 pp., £12.00

The Innovation Decision in Soviet Industry
Joseph S. Berliner
Cambridge: The M.I.T. Press, 1976, 561 pp., $35.00

Reviewed by Robert M. Cutler

The assessment of Soviet technological performance is not without pitfalls. The state of Soviet engineering technology, for example, should not be judged by the poor performance of the stereophonics industry — or of other industries in the consumer sector. Resources are allocated on a priority basis in the Soviet economy, and consumer goods simply have a low priority. On the other hand, Soviet technology in priority sectors is often as advanced as any on the globe. Engineering and military technology are the most advanced sectors in the U.S.S.R., and some Western firms have purchased Soviet technology in such areas as long-distance pipeline and power transmission.

Political Reform

Economic growth in any economy depends largely on the rate of change over time in the ratio of total output to total input; and the most important element explaining output growth, aside from input growth, is technological change. A striking feature of Soviet economic structure is its suitability for an economy *un*concerned with technological change. Striking, too, is the fact that the rates of growth of the principal inputs to the Soviet economy — labor force, capital stock, and energy supplies — are all decreasing. Such a situation only enhances the significance of technological change in economic growth.

If future economic growth depends upon technological change, Soviet leaders have only two ways to sustain and increase it: fundamental reform of the system to encourage the development of new technology, and increased importation of technology. They appear to be following both routes.

History suggests that economic reforms to promote innovation will have only marginal effects. Indeed, although the organizational reform introduced in 1973 may alleviate some barriers to technological innovation in the U.S.S.R., it involved only one of the four structural elements which Dr. Berliner proposes be used to analyze diverse national economies. The reform left untouched problems with other than organizational causes.

Dr. Hutchings addresses the interaction of science, technology, and design in the Soviet context. He explains very well both the evolution and current meaning of that concept in the Soviet experience, but it is questionable whether his conclusion should be generalized beyond the consumer goods industries. That conclusion is that the convergence of science, technology, and design has been "obstructed rather than aided by political pressures."

Impact of Imported Technology

The promise of imported technology is ambiguous. Ever since Peter the Great, the

Russian state has alternated relative isolation from the world with brief periods of intensive contact. Those periods of contact involved, among other things, the transfer to Russia of Western technology. The Soviet Union has during this decade initiated yet another period of such contact and become a burgeoning market for advanced technology from capitalist countries. But even in this situation, Western capital currently accounts for only about 5 per cent of all new capital investment in the U.S.S.R. On the other hand, because they are a very small proportion of the total, projects using imported technology can be given high priority.

One Western study indicates, for instance, that the marginal productivity of Western capital in the U.S.S.R. is generally eight to 14 times that of Soviet capital. Another study demonstrates that between 1960 and 1975 the U.S.S.R. imported and installed $2 billion worth (1973 U.S. prices) of mineral fertilizer technology, and that this had the net effect of increasing agricultural output by $4 billion *per annum*. The main Soviet industries using imported technology are chemical, shipping, motor, computers, oil and gas extraction, and transport.

Despite the immense leverage of foreign technology, it is nevertheless safe to predict that the net benefits of such imports will, apart from gains to trade, be rather modest. The spillover of imported techniques into native Soviet technology will vary depending on the industry involved and on the political will to push it. In the noncompetitive Soviet market, such spillover will generally be small; but, with the 1973 reform, the Soviets could conceivably develop domestic techniques more easily in light of their experience with Western technology.

The U.S.S.R. can use the gains to trade from foreign technology; its only other devices for balancing foreign payments are gold sales, arms sales, tourism, and shipping. We can reasonably predict that the U.S.S.R. will continue and perhaps increase its importation of foreign technology. The Director of Foreign Trade for the U.S.S.R. Ministry of Science and Technology would not otherwise have had a leave of absence in 1977–78 to do graduate work at the Sloan School of Management.

Robert Cutler received his S.B. degree from M.I.T. in 1973 and is currently studying for his doctorate in the Department of Political Science at the University of Michigan. □

Back to Aardvark and Zymurgy

Allan Gottlieb studied mathematics at M.I.T. (S.B. 1967) and Brandeis (A.M. 1968, Ph.D. 1973); he is now Assistant Professor of Mathematics and Coordinator of Computer Mathematics at York College of the City University of New York. Send problems, solutions, and comments to him at the Department of Mathematics, York College, Jamaica, N.Y., 11451.

In October I asked readers to report which types of problems are most (and least) favored. The response, although light, has been interesting. The chess and bridge problems received almost all the attention. But there was no consensus: about half of the respondents considered chess and bridge problems to be among the best while the other half placed them among the worst. Far fewer people mentioned the "finite" problems — i.e., those where it is possible (with a calculator or computer, perhaps) to try all the possibilities: most of the comment on these was favorable. Geometry problems were also mentioned, but — like chess and bridge — I can't read any clear preference.

Leon Bankoff has kindly sent me a photograph of R. Robinson Rowe taken at a recent conference. Regular readers will appreciate how pleased I am to have it.

The solution given in October to **NS12** contains an inaccuracy. See "Better Late Than Never" for details.

Problems

Y1979 This being the first issue for the new year, we begin with our yearly problem: form as many as possible of the integers from 1 to 100 using the digits 1, 9, 7, and 9 once each (thus 9 will be used twice) and the operators +, −, * (multiply),/ (divide), and ** (exponentiation). We desire solutions containing the minimum number of operators; and, for a given number of operators, solutions using the digits in the order 1, 9, 7, and 9 are preferred. The solutions to **Y1978** are given below.

NS 14 This problem was first published as **1976 FEB 2**, and Eric Jamin is still waiting for an answer: How many sequences can be formed using the 28 dominoes? We require legal (in the domino-theoretic sense) sequences. The proposer feels that the answer is 7,959,229,931,520, and that an important quantity to calculate is the number of complete closed routes that exist on a complete 7-gon (a heptagon with all its diagonals). If you wish to reduce the problem to a complete 7-gon, that is fine. But you must show us how to calculate the number of complete closed routes.

FEB 1 We begin this month's regular selection with a very famous chess problem from Steven Ross, who asks you to find a knight's tour. That is, with one knight placed on an empty board, make 63 moves that result in the knight having been on each square once. I might add that you could try to have the knight end on a square from which it can go to its original square; or for even more fun try to avoid having the knight cross its own path (but in this variation don't expect to be able to cover all 64 squares).

FEB 2 Next we have a geometry problem from Norman Spencer: Given an equilateral triangle ABC with an interior point P located 3, 4, and 5 inches from A, B, and C, respectively, what is the length of a side of the triangle?

FEB 3 Victor Sauer submitted the following "entertaining" problem, which he credits to someone else; but unfortunately I cannot read his handwriting at that point. There are nine suspects in a certain crime. When questioned, each answers as follows:

John: "Elvis is guilty."
George: "It was not Elvis."
Ringo: "I did it."
Paul: "It was either Ringo or Tommy."
Elvis: "George isn't telling the truth."
Fabian: "Ringo is guilty."
Chubby: "It was not Ringo?"
Tommy: "It was neither Ringo nor I."
Ricky: "Tommy is telling the truth, and it wasn't Elvis either."

Only three of these nine are telling the truth. That being so, who committed the crime?

FEB 4 Here is a real calculator problem from Bruce Andeen:

An interesting problem to try on scientific calculators is the generation of integers without the use of integer keys, the arithmetic operators (+, −, ×, ÷), or summation keys. For example, on an HP-45 one is excluded from using any of the bottom four rows of keys. Several problems can be posed:

☐ The number of different ways of generating a particular integer.
☐ The minimum number of keystrokes necessary to generate a particular integer.

Two very intriguing ones are:

☐ The minimum number of keystrokes necessary to generate the numbers 1 through 10 (not necessarily in sequence).
☐ The largest integer of a sequence that starts from 1 that can be generated.

Three comments are necessary for clarification: obviously, solutions vary with the calculator used; on machines with dual function keys, use of a "gold" (or whatever) key and another key constitutes two keystrokes; and numbers must be generated such that the round-off capability of the machine is not used — i.e., the numbers must be integers within the total display capability of the machine.

FEB 5 We close with a solid geometry problem from Eric Osman. Consider n points on the surface of a sphere, free to move anywhere on the sphere's surface. The problem: if n = 5 and the points repel each other (that is, they assume positions that maximize the minimum distance between any two of the n points), where will the points go? For n = 2, they go to the ends of a diameter. For n = 3, they wind up on a great circle and form an equilateral triangle. For n = 4, the points move to the vertices of a tetrahedron. But what about n = 5?

Speed Department

FEB SD 1 Ronnie Rybstein has A, B, and C line up so that A can see B and C, B can see C, and C can see no one. Mr. Rybstein then announces that he has three black hats and two white ones. While A, B, and C are not looking, Mr. Rybstein places one hat on each of their heads. He then asks each what color his hat is. A reports that he cannot determine this, and B gives the same answer. What is the color of C's hat?

FEB SD 2 Mr. and Mrs. D. Szper have two poles in their yard (and neither one is the Pope — ed.) with 150 feet of rope strung from the top of one to the top of the other. Each pole is 100 feet tall. How far apart are the poles if the lowest point of the rope is 25 feet from the ground?

Solutions

Y 1978 Form as many as possible of the integers from 1 to 100 using the digits 1, 9, 7, and 8, according to the same rules which are given above for **Y 1979.** There

is agreement that 24 of the numbers cannot be formed. An optimal solution for the 76 possible numbers is:

1. 1**978
2. 81 − 79
3. 9 − 7 + 1**8
4. 91 − 87
5. (91/7) − 8
6. 7 − (1**98)
7. (71 − 8)/9
8. (1**97)*8
9. (1**97) + 8
10. (79 + 1)/8
11. 1 + 9 − 7 + 8
12. (97 − 1)/8
13. 91 − 78
14. 7*18/9
15. 1 + 98/7
16. 97 − 81
17. 17*(9 − 8)
18. 89 − 71
19. 19*(8 − 7)
20. 19 − 7 + 8
21. (91/7) + 8
22. —
23. 9 + 7 + 8 − 1
24. 1*9 + 7 + 8
25. 1 + 9 + 7 + 8
26. —
27. 98 − 71
28. —
29. —
30. —
31. —
32. —
33. —
34. 19 + 7 + 8
35. 91 − (7*8)
36. 18*(9 − 7)
37. (7*8) − 19
38. —
39. (7 − 1)*8 − 9
40. (8 − 1)*7 − 9
41. —
42. —
43. —
44. —
45. (7*9) − 18
46. (7*8) − 9 − 1
47. (7*8) − (1*9)
48. 1 − 9 + (7*8)
49. 7**(18/9)
50. —
51. —
52. —
53. —
54. 71 − 9 − 8
55. (8*9) − 17
56. 1 + (9*7) − 8
57. (1**9) + (7*8)
58. (8 − 1)*7 + 9
59. 78 − 19
60. —
61. 79 − 18
62. (1 + 9)*7 − 8
63. 7*81/9
64. (17 − 9)*8
65. 81 − 9 − 7
66. 1 + 9 + (7*8)
67. —
68. 87 − 19
69. 78 − (1*9)
70. 1 − 9 + 78
71. 79 − (1*8)
72. 89 − 17
73. (1 + 9)*8 − 7
74. 9*(8 + 1) − 7
75. 19 + (7*8)
76. 91 − 8 − 7
77. 87 − 9 − 1
78. (1**9)*78
79. 97 − 18
80. 79 + (1**8)
81. 98 − 17
82. 89 − (1*7)
83. 89 − 7 + 1
84. —
85. —
86. 79 + 8 − 1
87. (1*9) + 78
88. 1 + 9 + 78
89. (8*9) + 17
90. 1 + 97 − 8
91. 98 − (1*7)
92. 98 − 7 + 1
93. —
94. —
95. 87 + 9 − 1
96. (19 − 7)*8
97. 19 + 78
98. 98*(1**7)
99. (18 − 7)*9
100. —

Responses were received from Warren Lane, Harry Zaremba, David Schoengold, Mike Bercher, John Rudy, Harry Hazard, Avi Ornstein, Gardner Perry, A. Holt, and Charles Rivers.

OCT 1 Conventional point counting (in bridge) gives four points for each ace, three per king, two per queen, and one per jack. The average bridge hand has ten such points. What is the probability of receiving a hand with exactly ten points?

Everyone agrees that the probability is about 9 per cent. Several computer programs confirm Harry Zaremba's careful calculation that the exact answer is 59,723,754,816 / 635,013,559,600. His solution follows:

Let the letters A, K, Q, J, and X designate an ace, king, queen, jack, and any card which has no points, respectively. There will be $52 - 4 \cdot 4 = 36$ cards which have zero points. In the table are the card distributions in a bridge hand that will total exactly ten points and the number of combinations for each distribution:

Number	*Distribution*	*Combinations*
1	2A + Q + 10X	6,100,484,544
2	2A + 2J + 9X	3,389,158,080
3	A + 2K + 10X	6,100,484,544
4	A + K + Q + J + 9X	24,100,679,680
5	A + K + 3J + 8X	1,936,661,760
6	A + 3Q + 9X	1,506,292,480
7	A + 2Q + 2J + 8X	4,357,488,960
8	A + Q + 4J + 7X	133,562,880
9	3K + J + 9X	1,506,292,480
10	2K + 2Q + 9X	3,389,158,080
11	2K + Q + 2J + 8X	4,357,488,960
12	2K + 4J + 7X	50,086,080
13	K + 3Q + J + 8X	1,936,661,760
14	K + 2Q + 3J + 7X	801,377,280
15	4Q + 2J + 7X	50,086,080
16	3Q + 4J + 6X	7,791,168
Total combinations of C =		59,723,754,816.

The total number N of different card combinations which could occur in a bridge hand is

$$N = \binom{52}{13} = 635{,}013{,}559{,}600.$$

Thus, the probability of receiving a hand with exactly ten points is

$P = C/N = 59{,}723{,}754{,}816 / 635{,}013{,}559{,}600 = 0.09405.$

Also solved by Tom Weddell, Scott Nason, Judith Longyear, Raymond Kinsley, S. Turner Smith, Gerald Blum, Michael Jung, Richard Hess, Alan LaVergne, Dennis Kluk, and the proposer, William Butler.

OCT 2 Find two positive rational numbers the sum of whose cubes is 6. In other words, find positive integers a, b, c, and d satisfying $(a/b)^3 + (c/d)^3 = 6$.

Despite one reader's proof of nonexistence, everyone else found the same answer. Although many of the solutions were based on a computer search, Richard Hess was able to avoid using either a computer or a great many trials by utilizing modulo arithmetic. His answer follows:

Assume a/b and c/d are reduced to lowest terms.

Multiply both sides by b^3d^3 => $a^3b^3 + c^3b^3 = 6b^3d^3$

Take the equation modulo d^3 => $c^3b^3 \equiv 0 \pmod{d^3}$

Take the equation modulo b^3 => $a^3d^3 \equiv 0 \pmod{b^3}$

$$(2) \Rightarrow \left.\begin{matrix} \text{d divides b} \\ \text{d divides d} \end{matrix}\right\} \Rightarrow b=d \Rightarrow a^3 + c^3 = 6b^3$$

with b relatively prime to a and c.

a and c must be odd and relatively prime =>

$$\left.\begin{matrix} a = p + q \\ c = p - q \end{matrix}\right\} \text{ p and q relatively prime}$$

$a^3 + c^3 = 6b^3 \Rightarrow 2p(p^2 + 3q^2) = 6b^3 \Rightarrow p(p^2 + 3q^2) = 3b^3$

Take each side modulo 3 ==> $p \equiv 0 \pmod 3$ ==> $p/q\ \{3(p/q)^2 + q^2\} = 9(b/3)^3$

Take each side modulo 3 ==> $p/3 \equiv 0 \pmod 3$ ==> $p/q\ \{27(p/q) + q^2\} = 3(b/3)^3$

Take each side modulo 3 => $p/q \equiv 0 \pmod 3$ ==> $p/27\{243(p/27)^2 + q^2\} = (b/3)^3$

Note that p = 27, q = 10, b = 21 works.

$(37/21)^3 + (17/21)^3 = 50653/9261 + 4913/9261 = 6.$

Also solved by Steven Feldman, Avi Ornstein, R. Smith, Bill Wilson, Mike Younkin, Eric Piehl, William Butler, Harry Zaremba, Raymond Kinsley, Judith Longyear, John Rule, Maury Goodman, Jack Crawford, Alan Lavergne, Michael Jung, Paul Dieges, Randall Rathbun, Dennis Kluk, Dennis Sandow, and Leon Bankoff.

OCT 3 The following cryptarithmetic problem consists of two mathematical statements which are correct in base 10 when digits are substituted for letters and are also true as read for modulo 9 mathematics:

SIX + TWO + TWO = ONE
SIX + SIX = TWO + ONE.

There was some confusion about the meaning of "is also true as read for modulo 9 mathematics." This is not a requirement for the values substituted to form a valid equation base 9. First of all, base 9 is not modulo 9. Secondly, the phrase "as read" precludes the substitution of digits for the letters. So this is just a normal base 10 problem with a coincidental truth when read modulo 9. Eric Piehl, however, was not confused by the wording and sent us the following solution: As this is base 10 arithmetic, we can substitute the first into the second:

SIX + SIX = TWO + SIX + TWO + TWO
or SIX = 3 · TWO.

Substituting this into the first equation

ONE = 5 · TWO.

As ONE is a three-digit number, T must be 1. We can test all possible values for TWO and check to see that all letters correspond to different numbers. Note that the "O" on ONE. Testing all possibilities:

(Continued on p. 94)

two two

105 × 5 = 525	105 × 3 = 315	126 × 5 = 630	126 × 3 = 378	136 × 5 = 685	136 × 3 = 308

one six

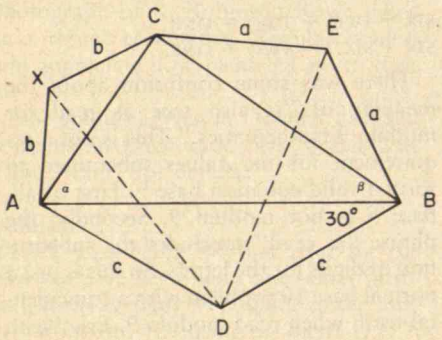
147 × 5 = 735	147 × 3 = 381	157 × 5 = 785	157 × 3 = 471	168 × 5 = 846	168 × 3 = 504
178 × 5 = 890	178 × 3 = 534	189 × 5 = 945	189 × 3 = 567	199 × 5 = 995	199 × 3 = 597

The only system that satisfies the above constraints is that in which

TWO = 178, ONE = 890, SIX = 534
giving 534 + 178 + 178 = 890
and 534 + 534 = 178 + 890.

Also solved by Judith Longyear, Raymond Kinsley, Harry Zaremba, William Wagner, William Butler, Harry Hazard, R. Smith, Winthrop Leeds, Bill Wilson, Mike Younkin, Eric Ranboy, Blaine French, Alan LaVergne, Jack Crawford, Emmet Duffy, Richard Hess, Gerald Blum, Maury Goodman and the proposer, Avi Ornstein.

OCT 4 Starting with *any* triangle, construct three exterior triangles having base angles of 30° and vertices at D, E, and X, as indicated in the diagram. If the distance DE is taken as 100, what is the distance DX?



Norman Wickstrand sent me a beautiful solution. Nothing unusual about that; but he added, as a final comment, that his solution is from his February, 1938, notes. As I mentioned in October, this problem first appeared in the *Review* in 1938, and Mr. Wickstrand, apparently anticipating my actions, saved his notes. Here they are:

$DE^2 = a^2 + c^2 - 2ac \cos(60° + \beta)$

$DX^2 = b^2 + c^2 - 2bc \cos(60° + \alpha)$

$DE^2 = a^2 + c^2 - 2ac(\cos 60° \cos\beta - \sin 60° \sin\beta)$
$= a^2 + c^2 - 2ac(\frac{1}{2}\cos\beta - \sqrt{3}/2 \sin\beta)$
$= a^2 + c^2 - ac\cos\beta + \sqrt{3}\sin\beta$

$DX^2 = b^2 + c^2 - bc\cos\alpha + \sqrt{3}\sin\alpha$

$\cos\alpha = [(2b\cos 30°)^2 - (2c\cos 30°)^2 - (2a\cos 30°)^2]/[2(2b\cos 30°)(2c\cos 30°)]$
$= (b^2 + c^2 - a^2)/2bc$

$\cos\beta = (a^2 + c^2 - b^2)/2ac$

$DE^2 = a^2 + c^2 - ac(a^2 + c^2 - b^2)/2ac - ac\sqrt{3}\sin\beta$
$= a^2/2 + c^2/2 + b^2/2 - ac\sqrt{3}\sin\beta$

$DX^2 = a^2/2 + c^2/2 + b^2/2 - bc\sqrt{3}\sin\alpha$

$(\sin\alpha)/(\sin\beta) = (2a\cos 30°)/(2b\cos 30°) = a/b$

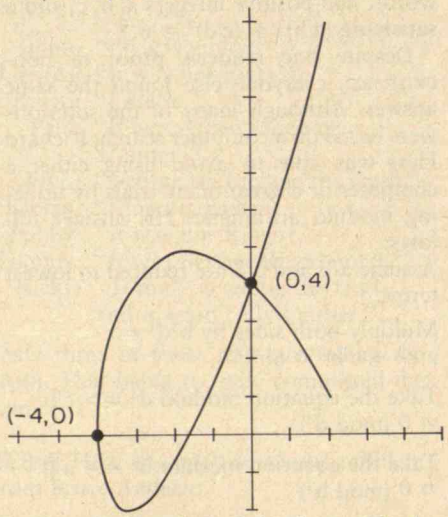
$\sin\alpha = a/b \sin\beta$

$DE^2 - DX^2 = \sqrt{3}(bc\sin\alpha - ac\sin\beta)$
$= \sqrt{3}(bc\,a/b\sin\beta - ac\sin\beta)$

$(DE^2 - DX^2)/\sqrt{3}\sin\beta) = ac - ac = 0$; therefore DE = DX = 100.

Also solved by Eric Ramboy, Paul Perkins, Harry Hazard, Norman William Butler, William Wagner, Edwin Comfort, Harry Zaremba, Smith Turner, Raymond Kinsley, John Rule, Maury Goodman, Gerald Blum, Richard Hess, Jack Crawford, Alan Lavergne, Sidney Shapiro, John Oehrle, M. Jung, Maomi Markovitz, Leon Bankoff and the proposer, J. Friedman.

OCT 5 Find the area of the loop of $y^2 = (x + 4)(x^2 - x + 2y - 4)$.



Our final solution is from Charles Rozier:
The equation can be rearranged into a quadratic in (y − x):

$(y - x)^2 - 8(y - x) - (x^3 + 4x^2 - 16) = 0.$

Solving the quadratic,

$y = x + 4 \pm x\sqrt{x + 4}.$

The loop lies between the two values of x for which y is single-valued, 0 and −4. If we let z equal the distance from the lower branch to the upper branch of y, then the area A is given by

$$A = \int_{-4}^{0} z\,dx = -2\int_{-4}^{0} x\sqrt{x+4}\,dx$$

Integrating (by parts with u = x, dv = $\sqrt{x + 4}\,dx$) yields

$$A = \left[-\frac{4x}{5}(x+4)^{3/2} - \frac{32}{15}(x+4)^{3/2}\right]_{-4}^{0}$$

$= 256/15.$

Also solved by Raymond Kinsley, Harry Zaremba, Eric Piehl, Norman Wickstrand, William Butler, Alan LaVergne, Kyle Roberson, Jack Crawferd, Richard Hess, Gerald Blum, Winthrop Leeds, Rob Newman, Michael Jung and the proposer, Harvey Elentuck.

Better Late Than Never

NS12 A. Walther's claim that the answer is approximately the fourth power of (1/e) is incorrect. His analysis of the one-suit case is correct and so is his answer that the value is approximately (1/e). But now his generalization to n suits is invalid (i.e., you cannot just raise the answer to the nth power). An easy way to see this is to take a simpler case having only two suits with three cards each and actually count the possibilities. You will see that Walther's formula for one suit (with 13 changed to 3) works fine but that the square is not the right answer for two suits. Comments were received from Ron Graham, Jack Parsons, M. Fountain, Edwin McMillan, and John Oehrle.

1977 J/A 4 John Oehrle has responded.

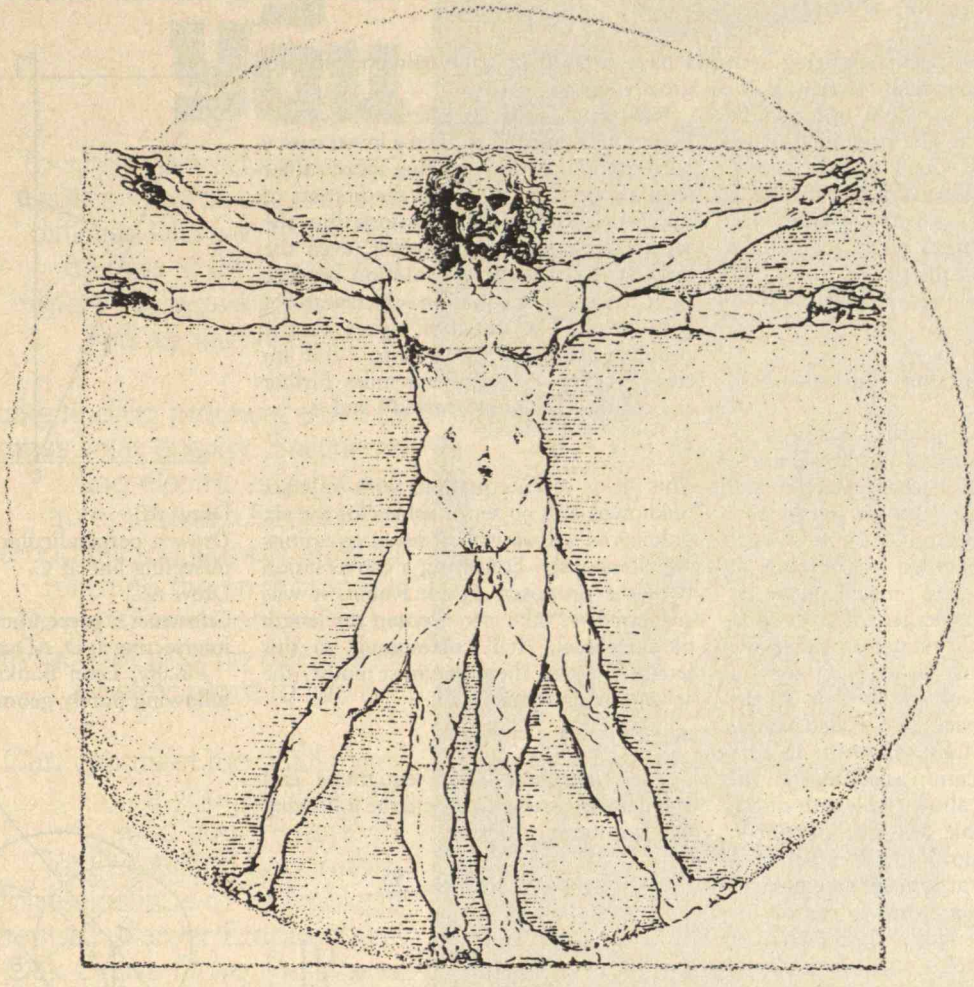
1978 JAN 3 Walter Delashmi has responded.

MAY 1 John Oehrle wonders if Black can draw by capturing the knight and allowing White to Queen. The answer is no since Queen verses Rook is a standard win.

M/A 1, M/A 3, and **M/A 5** John Oehrle has responded.

MAY 2 Samuel McCluney has responded and Charles Blake has submitted the following Greek-theoretic comment:
I was interested in one word; I assume that it is supposed that the words repre-

PROGRAMMER/ANALYST



PROVOCATIVE, POWERFUL, PERTURBING, SENSITIVE
HUMAN AND BEAUTIFUL

International Technical Professional Journal for Application Systems Analysts and Application Programmer/Analysts
Timely Commentary of Universal, Professional, Technical, Community, and Personal Significance
Technical Notes for State of the Art and Advanced Art Application Environments

FEA
ALEXANDER
INTERNATIONAL

Frank E. Alexander
CEREBRATONIA-RENAISSANCE PRESS
Chicago • Seattle • Toronto

sent pairs with two members being literally different in meaning. If that is the case, then one word does not qualify: Hedriophthalmous. The beginning of the word is from the Greek word "hedra" meaning "seat." However, since the "h" is not represented by a letter in Greek but merely by a diacritical mark, the word is more often spelt without the initial "h" but the two spellings are identical in meaning.

MAY 4 John Oehrle has responded.

J/J 2 The solution published has been severely criticized by Lloyd Furthmyer and a team consisting of Richard Pavelle and LeRoy Sievers. Begin with Mr. Furthmyer: No less than 19 persons submitted what you apparently regarded as solutions to this problem. But how, may I please inquire, do these people get off with completely ignoring the statement that the diesel train "has just passed" at the point seven miles out on the bridge as the pedestrian steps back to the first track? This statement is fully as worthy to generate a seventh equation as are most of the others, if we may allow the length of the train to be negligible. It is not, of course; but then, we did not know if either train had its locomotive at some precise point at the Aardvark or the Zymurgy stations. If we had taken the length of the diesel, or at least the time it took to pass the man, as negligible, then a seventh equation would have had to be reckoned with, namely $4/v = (a + 7)/v$. It is my belief that inclusion of this seventh equation makes the set not soluble. But there is an "out" to this: we simply add another unknown, the length of the diesel train. If we plug this seventh equation and unknown into your published solutions, the diesel train is, I believe, about 652 miles long in the first solution. But let us agree that this is the extraneous root of the equation, which often leads one astray into the hazy realms where small boys fish with poles of negative length while unmowing their neglected lawns. The second solution requires the diesel train to be only around 8.83 miles long — although uncommon, undoubtedly well within our mathematicians' license. What bothered me about this problem was the "inelegance." We are expected to *infer* that all speeds were constant and that the locomotives were precisely 25 miles apart at their respective stations. But this is scarcely reason to infer that we can ignore the seventh equation, even if we choose to ignore the length of the train or the time it takes to pass the man. This is the only badly stated problem I have noticed in your column, which I greatly enjoy.

Now for Messrs. Pavelle and Sievers: Equation (5) should contain a lower case v corresponding to the walking speed rather than a capital V. With this the first set of numbers satisfies the equations but the second set does not. However, even the first set is not a correct solution because there is a seventh equation which was not considered. The equation arises in the problem from the statements, "But instead I cross . . . walk four miles further . . . the diesel has just passed" and is

$$4/v = (a + 7)/V$$

This yields seven equations with only six unknowns and no set of values for the six unknowns will satisfy all seven equations simultaneously. Following a conversation with the proposer, Frank Rubin, it was suggested we take into account the length of the diesel. If T corresponds to this length in miles, then one must modify the seventh equation to read

$$4/v = (a + 7 + T)/V$$

There are now seven equations and seven unknowns which yield the following two non-trivial solutions:

$$\left[A = \frac{15}{2}, V = \frac{175}{4}, R = \frac{35}{2},\right.$$

$$\left.L = 10, T = \frac{53}{6}, W = \frac{175}{4}, v = \frac{15}{2}\right]$$

$$\left[A = \frac{35}{2}, V = \frac{175}{4}, R = \frac{15}{2},\right.$$

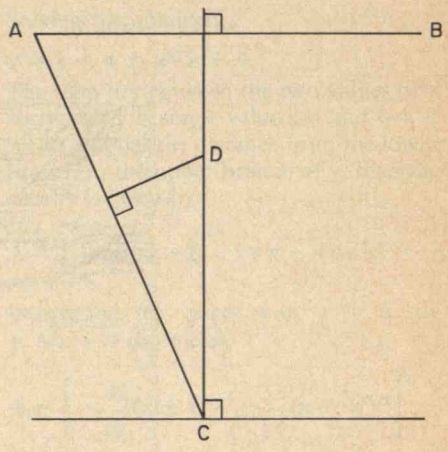
$$L = \frac{210}{29}, T = \frac{3913}{6}, W = \frac{225}{28},$$

$$\left.v = \frac{15}{58}\right]$$

although the second should be discarded since the length of the train is greater than 25 miles.

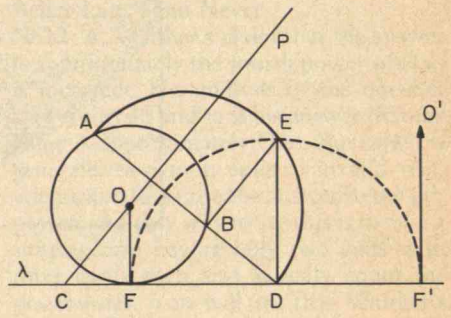
J/J 4 John Oehrle has responded.

J/J 5 John Oehrle and Samuel McCluney have responded, and Emmet Duffy makes the following remark:
The published answer has the same failing as the answer I submitted — there is no answer when a line joining the two given points is parallel to the given line. In the published solution the cosine of theta becomes zero and the radius r becomes indeterminate in the form 0/0. If the two points are so given that a line joining them is parallel to the given line, then the following solution applies:



Draw AB
Draw a perpendicular bisector of AB intersecting line at C.
Draw AC.
Construct a perpendicular bisector of AC intersecting at D. AD is the desired radius.

Finally, Leon Bankoff has sent us the following purely geometric solution:



The required circle can be constructed without recourse to trigonometric and algebraic involvements. Connect the two given points A and B and let CP, the perpendicular bisector of AB, cut the given line λ at C. Extend AB to cut λ at D. Then let the perpendicular to AD at B cut the semicircle on the diameter AD at the point E. With D as center and with DE as radius, describe an arc cutting λ at F. The perpendicular to CD at F will put CP at O, the center of the required circle. (As a gratuitous sidelight, if F′ is the second intersection of the arc (D)DE with the line λ, the perpendicular to λ at F′ will cut the line CP at O′, the center of the larger of the two circles through the two given points and tangent to the line λ.) *Proof:* The center O of the required circle must lie on CP, the perpendicular bisector of what will become the chord AB. From the relation $DE^2 = DB \cdot DA = DF^2$, it is apparent that the required circle will touch λ at F. (By Euclid, Book III, Proposition 36,

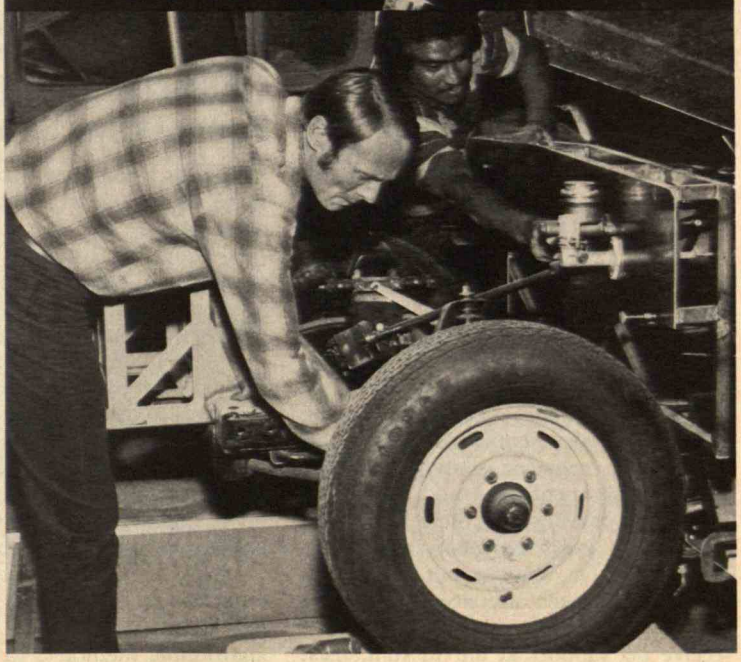
(Continued on p. 100)

We Challenge You

To apply your education and abilities to some exciting and difficult tasks we're working on here at JPL. Tasks that require innovative thinking as well as plain hard work.

Like finding practical ways to harness solar energy. Engineering electric and hybrid automobiles. Utilizing our abundant coal supply without harming the environment. Down-to-earth jobs with the lofty goal of making our planet a better place to live on.

Can you meet the challenge? If you feel you can, send your resume to: Jet Propulsion Laboratory, California Institute of Technology, Attention: Career Employment, 4800 Oak Grove Drive, Pasadena, CA 91103.



THERE'S ONLY ONE JPL

A Perilous Failure of U.S. Support for University Research

At a time when it's more needed than ever before, the research capacity of the nation's leading universities is being eroded by short-sighted government rule-making and budget cutting. The result is "a crisis of finances and morale" in university research, President Jerome B. Wiesner of M.I.T. told the National Council of University Research Administrators in Washington on November 9.

It was a rare venture into the national spotlight for Dr. Wiesner, who usually prefers to exert his considerable influence quietly. His audience of colleagues in university administration greeted the message with enthusiasm, and major newspapers were responsive. But the Washington-based press which serves most of those aggrieved by the policies which Dr. Wiesner criticized was curiously unsympathetic. Daniel S. Greenberg in *Science and Government Report* called it "an example of doomsday oratory . . . of gold medal caliber," and Eliot Marshall in *Science* seemed to find Dr. Wiesner petulant and almost self-serving.

Though Dr. Wiesner spoke of "a barrage of independent and unrelated government actions that . . . have had an adverse impact on the health of the university," his emphasis was reserved for new regulations just being proposed by the Office of Management and Budget (O.M.B.) in what is called Circular A–21, which sets forth how universities are to be reimbursed for direct and indirect costs of government-sponsored research.

O.M.B.'s proposals, Dr. Wiesner said, would "limit in a destructive way reimbursement for indirect costs that are necessary and essential"; they are "inequitable or administratively impracticable or both." The largest frustration is a change which would make students only "learners," never "the contributors they are to research activities." Thus indirect costs would no longer include expenses for services and libraries — for examples — for students in research assignments.

Other government actions cited by Dr. Wiesner included requirements for equal opportunity, rules for safety, controls on human experimentation, and changes in retirement patterns. All these have goals with which every university must sympathize, said Dr. Wiesner; but government initiatives in each are accompanied by financial costs toward which universities receive no support at all. In sum, these represent "a barrage of independent and unrelated government actions that . . . have an adverse impact on the health of the university.

"What we need, and what the country now needs," said Dr. Wiesner, "is regulation of regulation."

Why not let the universities shrug their shoulders and give up government-sponsored research, if they don't like the terms under which it can be done? Because today's scientific, technical, and social problems "create an urgent need for a new level of university research," Dr. Wiesner said. He cited two of many such problems for his audience of university administrators:

☐ The position of U.S. manufacturing industries in world markets is weakening, U.S. productivity is increasing only slowly, and our rate of innovation is declining.

☐ As conventional energy resources are depleted, we need new sources, and we are coming to understand that "energy is the quintessential systems problem," said Dr. Wiesner — the best current evidence that "we do not yet know how to manage a complex, democratic, industrial society.

"In general, university research, with its capacity to be comprehensive and with a credibility based on objectivity, can play an especially important role in studies clarifying for government the elements of conflicting societal goals. . . . University research has the potential to make truly extraordinary contributions to the progress and welfare of the American people." ☐

Optimizing Products: Keep Them Simple

How does a company manufacture something better — or cheaper — than its competitors?

Although much thought, effort, and research have been devoted to improving productivity in today's industries, there is still plenty of room for improvement, and President Jimmy Carter himself has made this a subject of special study in 1979. Researchers at M.I.T. who are working on this problem think they might have an important answer. By making a product easier to manufacture rather than just trying to make it cheaper, they hope to do a better job of making it cheaper.

Much research on increasing productivity has previously been directed toward developing what could be called "the algorithmic method": to obtain the best product for the least money, alternative processes are evaluated for costs; indeed, every possible combination of methods for producing an item is evaluated in the search for the lowest overall cost. This method, if perfectly executed, will result in the absolute lowest manufacturing cost on the basis of available technology. Unfortunately, the method requires accurate information about a vast number of alternative processes, and the results are valid only as long as the technology remains unchanged.

How, then, do the M.I.T. researchers propose to analyze productivity? Professor Nam P. Suh and his associates in the Laboratory for Manufacturing and Productivity approach the question this way: instead of looking for the minimum cost, find the best way of making a product. If the manufacturing method — and the product itself — are as simple as possible, yet still do everything intended, the goal has obviously been fulfilled.

The laboratory is now embarked on the search for a set of principles for obtaining this "simplest" product. The theory states that two rules or axioms, if satisfied at each step of designing a product, will lead to the ideal result. The two rules are simple, yet comprehensive:

☐ Requirements for the product must be identified. These include functional requirements — what does the product have to do? — and constraints or limits. For example, two functional requirements of a pocket knife are that it has a blade which can cut and that the blade folds so that the knife is safe in a pocket. Constraints might have to do with size and weight.

☐ Information must be minimized. As soon as the producer is satisfied that the product meets each requirement and constraint, his task is to make it as simple as possible, and to make all of the processes of producing and assembling it simple as well. Returning to the pocket knife example, a Swiss Army knife with a blade and ten other useful attachments will not be the best design: it is much more complicated than the single-blade pocket knife and does not fill the stated requirements any better. The idea is that if a product and its production are optimized, then the cost will necessarily be minimized.

These rules imply a new methodology which is now being tested against conventional design methods. The work will begin with an intuitive approach to the design process. But Adam C. Bell of the laboratory feels that design can be analyzed using a system approach, allowing a given design to be modeled in mathematical terms and solved for an op-

timum. In other words, he says, a solution would be obtained on the basis of functional requirements and constraints, which would have minimum information and therefore maximum efficiency of manufacture. — *Kevin R. Crystal, '79* □

Turning from Oil to Coal

How can coal be made to fill the "energy gap" that will confront the world when oil production peaks by 1990?

To answer the question, Carroll L. Wilson, Mitsui Professor in Problems of Contemporary Technology, Emeritus, in the M.I.T. Sloan School of Management, has assembled a global study team of 35 experts in industries, governments, and universities. Each has designated several associates to take part in research which will continue throughout 1979, and there will be a final report in March, 1980.

"We are in a race with time" to prepare for the age of coal, says Professor Wilson, and that race "is made more difficult because claims still abound that there is no energy problem that needs attention now." The coal study follows a similar world-wide study of global energy resources and demands made under Professor Wilson's direction in 1976–77 *(see "The Coming Energy Shortage," by Paul S. Basile and David Sternlight, June, 1977).*

Catalyzing Research

About a decade ago some 200 new, small technical companies were established in a single year, and the 1960s were a time of thriving along Massachusetts' Route 128, the "Golden Horseshoe" of high-technology industry around Boston.

Not so today. In the current, enervating climate for U.S. research and development, says Edward R. Kane, president of E. I. du Pont de Nemours and Co., we are experiencing a reduction in real economic growth, a slackening in productivity improvement, and "the virtual disappearance of new equity-financed small technical companies." Addressing an audience gathered at M.I.T. last fall for a program marking the 75th anniversary of the Institute's Research Laboratory of Physical Chemistry, he said, "Route 128 in its heyday symbolized a degree of vigor that has gone out of technology now."

What's the problem? Dr. Kane doesn't think it's a lack of talent or failure in the laboratories. Rather, in his view, some of the problem is caused by "malnourishment of basic science," but he attributes most of it to a weakening of incentives for moving discovery and invention into development, manufacture, and use. Universities and industry alike have been caught in a "downdraft" of adverse factors, among which Dr. Kane includes the falloff of funding for academic research, inflation, tax laws, and government regulations and constraints. All these pervade decisionmaking in technology-based firms — particularly, Dr. Kane says, "for the 'D' side of the R and D couplet, for it is here that the big costs are incurred." A consequence is that "many industrial research organizations today are concentrating their innovative efforts more on process research and cost-cutting technologies, where there is more certain payoff, and less on research which might point to entirely new lines of business."

A few hopeful signs: tax reform has improved some incentives for innovation, and Dr. Kane thinks there is a growing awareness of the need for federal support for research, more vocal public sympathy with industry's complaints about government regulation, and more attention to the research and development environment in forums that have political and economic clout.

Celebrating 75 years of physical chemistry at M.I.T. Just after Edward R. Kane (left center), president of du Pont, finished lamenting the "vigor that has gone out of technology now," he received congratulations from three members of the M.I.T. family: James L. Kinsey (left), Head of the Chemistry Department; John M. Deutch, who is on leave from the faculty to be D.O.E.'s Director of Energy Research and Development, and James A. Beattie (right), professor emeritus who taught physical chemistry for most of its first 75 years at the Institute — from 1917 to 1961.

But it was evident that Dr. Kane thinks these are not enough. "There is energy in this system," he said, "but the entropy needs to be increased, the controls relaxed, the catalysts applied." It is a matter of some urgency, he believes, because the stakes are "the scientific, technological, and economic strength of this country." — *William Struble* □

The Coming of the Age of Fusion

Electric power generation by fusion is no longer a question of "if"; it's just a matter of "when," according to Ronald R. Parker, Associate Director of the Francis Bitter National Magnet Laboratory where a major fusion project called Alcator is under way.

For the Joint Committee on Energy of the Vermont legislature, Professor Parker early this winter predicted a demonstration of fusion power before the year 2000. But, he said, fusion will not contribute significantly to electric production until at least 20 years later. □

Classified

PROFESSIONAL

WHEN YOU NEED HELP GETTING HELP

In any technical field, call (215) 735-4908. We have been placing carefully selected engineers, chemists, scientists, metallurgists and technical sales people in all fields since 1959 . . . and we can do the same for you.

No charge unless we fill your position. Over 1000 client companies count on our technical staff for help. You can, too. Call today, or request our new brochure.

A. L. Krasnow, '51, Pres.

ATOMIC PERSONNEL, INC.

Suite T, 1518 Walnut St., Phila., Pa. 19102

An Employment Agency for All Technical Fields

WE ARE CONSTANTLY SEARCHING FOR:

- Engineers: EE's, ME's, CHE's
- Scientists
- Computer Professionals
- MBA's
- Financial Specialists

Submit your resume and salary history to:

Martin Lyons Personnel Services, Inc.

234 No. Main Street
Mansfield, Mass. 02048
(617) 339-9301
714 Washington Street
Norwood, Mass. 02062
(617) 762-4100

You're Boxed In

Your career is blocked. You're frustrated and insecure. Time is going by and things aren't getting better.

You need to find a better way. You need new objectives for yourself and new strategies for achieving your objectives.

That's my job. I am a management consultant, specializing in change, and I have helped hundreds get out of that box and onto a more satisfying career and life path.

Write for free brochure T11, "Get Out of that Box — Now!", or telephone for an appointment. Don't wait. Do it now.

Riva Poor, SM Management, MCP, from MIT

Private programs. Also 2-day weekend workshops. *(See p. 15 for details.)*

Riva Poor Associates
73 Kirkland Street
Cambridge, Ma 02138
Telephone: (617) 868-4447

NATIONWIDE

PROFESSIONAL PLACEMENTS

- Hardware Engineers
- Software Engineers
- Technical Writers
- Technicians

JUDGE

ELECTRONICS SERVICES, INC.
Two Newton Executive Park
Newton,MA 02162

(617) 965-9700

HOW TO EARN MONEY AS A CONSULTANT
(including specimen contracts) $25.
Business Psychology International
890/13 National Press Bldg., Washington, D.C. 20045

AVAILABLE FOR NEGOTIATIONS

Attorney-At-Law
High Technology Experience
SPOKEN CHINESE
Daniel M. Schaeffer, '42 ChE
14 Elkin Drive
Middle Island, N.Y. 11953

SYNTHETIC LUBRICANTS

Auto — Commercial — Marine
Direct sales dealership. Retail, Wholesale basis. Full line of 100% pure (non-petroleum) ester lubricants. No quotas. Start part-time, build to full-time. (Product promotion plan includes TV and major magazine advertising in early 1979.) Respond to R. Cabacoff, 255 North Road #124, Chelmsford, MA 01824 617-256-7788

PUBLICATIONS

BUSINESS ADVENTURES. Free book catalogue. Simtek, Box 109-H, Cambridge, MA 02139

MARTIAN SUNSET, LUNAR EARTHRISE

Genuine NASA Viking & Apollo high-quality FULL COLOR ART PRINTS. 22" x 34" Ideal for permanent framing & display. Beautiful. $10.95 each plus $2.05 insured postage.

WOODSTOCK PRODUCTS

P.O. Box 4087, Dept. TR3, Beverly Hills, CA 90213

Classified Ads: $3.00 per line; two-line minimum. (Allow 32 letters & spaces for first line; 50 letters & spaces for each additional line.)

Display Ads: $25.00 for first column inch; $20.00 for each additional inch.

Copy Deadline: one month prior to publication date. Payment in advance of insertion required for less than three insertions in one year. Send orders to Classified Section, *Technology Review*, M.I.T., Room 10-140, Cambridge, Mass. 02139.

Puzzle Corner

(Continued from p. 96)

the square of a tangent from a point to a circle is equal to the product of the secant from the same point and the external segment of the secant.) The same argument applies to the construction of the larger circle centered at O′, for which the square of the tangent DF′ is equal to the product of the secant DA and the outer segment DB.

A/S 1 Alan LaVergne, Nick Michael, Jacob Bergman, Roger Lipsett, John Oehrle, Ben Rouben, and G. Saulnier have responded.

A/S 2 Alan LaVergne, Jacob Bergman, Jack Crawferd, and Roger Lipsett have responded.

A/S 3 John Oehrle, Naomi Markovitz and Alan LaVergne have responded.

A/S 4 Ivor Morgan, Dave Stolfa, Emmet Duffy, Roger Lipsett, Alan LaVergne, and Jacob Bergman have responded.

A/S 5 Alan LaVergne, Naomi Markovitz, Jack Crawferd, Jacob Bergman, Roger Lipsett, and Emmet Duffy have responded.

Proposers' Solutions to Speed Problems

SD 1 Since A cannot determine his hat color, either B or C must have a white hat. B knows this but still cannot determine his hat color. Thus C must have a white hat. (Answer courtesy of the editor.)

SD 2 Zero feet. (Answer courtesy of the editor.)

14 factors that could affect the performance of your next prescription.

Before you ask your pharmacist for a cheaper version of the medication prescribed by your doctor, consider.

In making the "same" drug, different companies may exercise different levels of skill and care. They formulate and manufacture the "same" product differently.

Change the inactive ingredients, compress the tablets too much, make any of a dozen other misjudgments, and the resulting product may cause problems. Yet it could look just like a well-made drug.

That's why it's vital to control factors like the few we've listed. To assure quality in every prescription drug, at every stage from research lab to pharmacy shelf.

PMA believes every company should be required to document the biological performance of its products and identify the actual manufacturer on the package label. Because the manufacturer's competence is the key to quality.

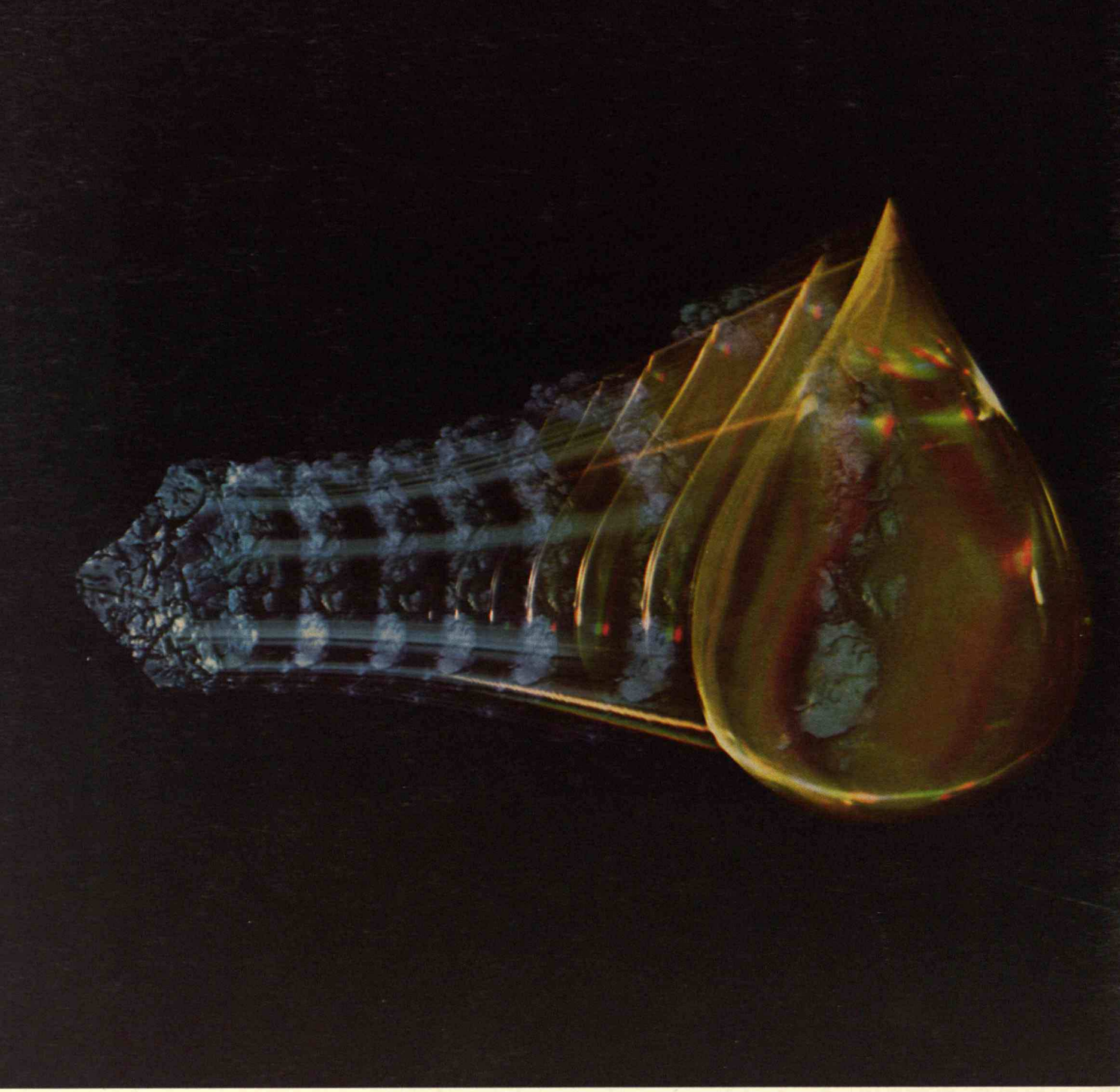
To know you're getting a drug of assured quality at an acceptable price, ask your doctor and your pharmacist. These professionals know drugs. And they know drug companies from long experience.

They know that established firms—those with proven quality assurance programs—produce consistently reliable medicines. Such products sometimes cost a little more. But in drug therapy as in drug manufacturing, a saving at the expense of quality could be the worst kind of economy.

The Pharmaceutical Manufacturers Association.

If a new medicine can help, we're working on it.

With your health at stake, you may want to know more. Please write for our "Key Facts" booklet. It's free. The Pharmaceutical Manufacturers Association, Dept. TR-902, 1155 Fifteenth St., N.W., Washington, D.C. 20005.



"There is nothing permanent except change."

Heraclitus

The Greek philosopher said it 2500 years ago. And all the changes since then have proved him right.

Consider America's energy situation: As petroleum becomes harder to find, we are turning to that old standby—coal. But today Conoco is producing coal with technology that yesterday's miners never dreamed of.

For example, working together, our petroleum and coal engineers have developed an underground pipeline system that mixes coal with water and pumps it out of the mine, safer and faster.

We're also working on ways to change coal into other useful forms, such as synthetic gas and oil.

And since America's need for energy will continue to grow, Conoco is active in other fields as well—from producing uranium to developing oil from tar sands.

At Conoco, we don't just adapt to change; we help shape it.

conoco

Doing more with energy.

To learn more about what we're doing with energy, write Dept. G, Continental Oil Company, Stamford, Conn. 06904.